4 May 2007

Mr. Devender Narala
California Regional Water Quality Control Board, San Francisco Bay Region
1515 Clay Street, Suite 1400
Oakland, California 94612

Subject: Field Sampling Plan for Former Building 970, dated May 2007
Presidio of San Francisco, California

Dear Mr. Narala:

Enclosed please find one copy of the *Field Sampling Plan for Former Building 970, Presidio of San Francisco, California*, dated May 2007, prepared by EKI for the Presidio Trust (Trust).

The Trust is submitting this field sampling plan to address residual petroleum impacts around the FDS removal area near Former Building 970. Once we receive approval of this work plan, we will prepare and conduct the proposed field investigation. We hope to conduct the field sampling in late Spring 2007. The project manager for the Trust for this project is Jennifer Yata. Please contact me at (415) 561-4259 if you have any questions.

Sincerely yours,
The Presidio Trust

Original signed by

Craig Cooper
Remediation Program Manager

Enclosure

cc (with enclosure):
Bob Boggs, Department of Toxic Substances Control (DTSC)
Brian Ullensvang, National Park Service (NPS)
Doug Kern, Restoration Advisory Board (RAB)
Mark Youngkin, RAB (cover letter only)

Erler & Kalinowski, Inc.
Consulting Engineers and Scientists
1870 Ogden Drive
Burlingame, CA 94010
(650) 292-9100
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4 May 2007

Ms. Jennifer Yata
Presidio Trust
34 Graham Street
Post Office Box 29052
San Francisco, California 94129-0052

Subject: Field Sampling Plan for Former Building 970/971 Area
Presidio Trust, San Francisco, California
(EKI A70004.17)

Dear Ms. Yata:

Erler & Kalinowski, Inc. ("EKI") is pleased to present this Field Sampling Plan ("FSP") for the investigation of petroleum-impacted soil near Former Building 970/971 Area of the Presidio of San Francisco.

If you have any questions please do not hesitate to call.

Very truly yours,

ERLER & KALINOWSKI, INC.

Michelle King, Ph.D.

Vice President

John DeWitt, P.E.
Project Manager

REGISTERED PROFESSIONAL ENGINEER
JOHN THOMAS DE WITT
C055468
Exp. 12/31/08
CIVIL
STATE OF CALIFORNIA

FIELD SAMPLING PLAN
FORMER BUILDING 970
AT THE PRESIDIO OF SAN FRANCISCO

Prepared for:

Presidio Trust
San Francisco, California
(EKI A70004.17)

4 May 2007

FIELD SAMPLING PLAN
FOR FORMER BUILDING 970/971 AREA AT THE PRESIDIO OF SAN FRANCISCO

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1.0 INTRODUCTION AND BACKGROUND

On behalf of the Presidio Trust (“Trust”), Erler & Kalinowski, Inc. (“EKI”) has prepared this Field Sampling Plan (“FSP”) for soil and groundwater sampling and chemical analysis from seven locations at the former Building 970/971 Area (“Site”). The Site is located near the intersection of Long Avenue and Lincoln Boulevard, within the Golden Gate / Fort Point Planning District, and within Area A, which is under the jurisdiction of the National Park Service (“NPS”). The results of soil and groundwater sampling and chemical analysis described herein will be used to evaluate lateral and vertical extent of chemical impacts to soil and groundwater, as well as whether further remedial actions are appropriate.

The scope and objectives of the Building 970/971 Area FSP were developed in consultation with the Trust and the NPS. This FSP will be provided to the Regional Water Quality Control Board, San Francisco Bay Region (“Water Board”), Department of Toxic Substances Control (“DTSC”), and members of the Restoration Advisory Board (“RAB”) for input prior to implementation of this work. Collectively, these parties are referred to as the “stakeholders.” The scope of work will be conducted in accordance with the Presidio-wide Quality Assurance Project Plan (“QAPP”) (TTEMI, 2001).

Building 970 was a 470,000 gallon fuel oil above ground storage tank (“AST”) constructed of concrete that was removed by the Army in October 1996. Associated piping and a pump house identified as Building 971 were also removed. The Army excavated approximately 95 cubic yards (“cy”) of soil from beneath the tank, to depths of up to 11 feet and collected soil confirmation samples (IT, 1998). All confirmation samples the Army collected from below the tank were below applicable cleanup levels, and the sample location and results are posted on Figure 2. The excavation was backfilled with 95 cubic yards of low-temperature thermal desportion (“LTTD”) treated soil. The Army also removed the fuel distribution system (“FDS”) piping leading to the pump house, and collected a soil sample near the former pump house (location FM02010L01 shown on Figure 2). The Army removed the FDS piping north of AST 970 in March 1997, and conducted soil excavation down slope (northeast) of the tank, to the top of the competent serpentine bedrock at a depth of approximately 13 feet below ground surface (“ft bgs”). Four test pits were dug within the excavation and soil above applicable cleanup levels was identified. Residual soil with total petroleum hydrocarbons as diesel (“TPHd”), total petroleum hydrocarbons as fuel oil (“TPHfo”), and polycyclic aromatic hydrocarbons (“PAHs”) above applicable cleanup levels remain in the soil. Soil data collected by the Army is posted on Figure 3. The over excavation around the pipeline was also backfilled with approximately 850 cubic yards of LTTD treated soil.

No groundwater investigation or sampling has been conducted at the Site to date. The depth to groundwater is unknown, and since the applicable cleanup levels for petroleum hydrocarbons are a function of depth to groundwater, the exact cleanup levels are uncertain. Therefore, an accurate understanding of the Site hydrogeology is necessary to determine applicable cleanup levels and evaluate whether further remedial actions are appropriate.

Cleanup levels for petroleum hydrocarbons in soil at the Presidio are presented in the Site Cleanup Requirements prepared by the Regional Water Quality Control Board, San Francisco Bay Region ("Water Board") in Order No. R2-2003-0080 ("the Order"). The Order includes cleanup levels for petroleum and related constituents for the protection of human health, terrestrial receptors, and water quality. The cleanup levels for petroleum compounds are summarized in Table 7-5 from the Presidio Cleanup Level Document (EKI, 2002). A copy of this table is included in Appendix A.

The planned land use at the Site includes recreational and ecological (i.e., terrestrial receptors). Thus, in accordance with the Order, the soil cleanup levels applicable to the Site for protection of human health and ecological populations include recreational values to a depth of 2 feet bgs and ecological (terrestrial) values to a depth of 3 feet bgs. As shown on Figure 3, the most stringent applicable soil cleanup levels are the ecological criteria for the top 3 feet bgs.[1] Recreational human health values then apply to ten ft bgs, unless groundwater is within five feet. The Trust will also compare analytical results to residential cleanup levels to potentially reduce the need for land use restrictions (which could apply if residential cleanup levels are not achieved). If groundwater is encountered, the soil cleanup levels within five feet of groundwater are the values for the protection of groundwater resources (outside Crissy Field and Lobos Creek areas). Thus, the depth to groundwater is required to determine applicable cleanup levels at this Site.

Data from Army soil samples collected from the excavations in 1996 and 1997 are shown on Figures 2 and 3. Soil sample locations which exceeded cleanup levels (on Figure 3 only) are shown with a circle around the triangular sample location marker.

Data collected from the 1997 excavation activities indicates that residual TPHd and TPHfo concentrations of up to 21,000 mg/kg and 9,700 mg/kg in soil exceeded the applicable cleanup levels of 3,200 mg/kg and 4,500 mg/kg, respectively. Some soil samples were analyzed by immunoassay kits, and the TPH and PAH concentrations in the soil samples exceeded the upper range limit, so the actual concentrations of these chemicals are unknown at specific locations.

The objectives and rationale of the soil sampling and testing program are described in the Data Quality Objectives section, below.

[1] Although the area is recreational, the Army met human health residential cleanup levels for the remaining soil beneath former AST 970, as shown by the data posted on Figure 2, assuming groundwater is greater than five feet below the sample locations.

2.0 DATA QUALITY OBJECTIVES

Three groundwater and four soil sample locations are proposed at the Site, as shown on Figures 2 and 3. The following data quality objectives ("DQOs") summarize the additional data needed to further characterize the Site:

- Groundwater DQOs: Site groundwater has not been characterized to date. Sampling is proposed to determine the depth to groundwater at three locations and install groundwater monitoring wells if groundwater is encountered at less than 40 ft bgs. The groundwater monitoring wells will allow the measurement of groundwater elevation, flow direction, and potential chemical impact to the groundwater. If chemical impacts are identified, the change in concentration over time can be measured with groundwater monitoring wells.

- Soil DQOs: The lateral and vertical impact of petroleum hydrocarbons and PAHs is not clearly defined. Soil borings are proposed within 5 to 10 feet from locations where previous samples indicated that TPH or PAHs exceeded applicable cleanup levels, or the previously identified chemical impact was not bounded. Soil samples will be collected at five foot intervals for logging and screening with an organic vapor monitor ("OVM"). Soil analysis for stained or odorous samples will be collected from maximum depth of the stained region and 5 and 10 feet below the stained region.

The DQOs are presented in more detail in Table 1.

3.0 FIELD ACTIVITIES

3.1 Pre-Field Activities

To prepare for the environmental sampling described in this FSP, prior to field activities, the Trust will provide access to sampling locations. The Trust, NPS, and EKI will select sampling locations in the field; the Water Board, DTSC, and RAB will be invited to the field meeting to provide field input if they choose. EKI will contact Underground Service Alert prior to the initiation of subsurface work, and the utility owners and Trust Utility Department will provide utility clearance. EKI will update its site specific health and safety plan, and prepare subcontracts with the California-licensed drilling contractor.

3.2 General Field Procedures

As described above, EKI will collect soil and groundwater samples from up to 7 locations in accordance with the field methods and procedures outlined in Attachment A and as specified in Standard Operating Procedures ("SOP") SOP 001 through SOP 005,

SOP 009, SOP 013, SOP 014, and SOP 015 of the QAPP (included as part of Appendix B). Due to the restricted access and steep slopes, drilling for soil borings and groundwater monitoring wells at the Site is planned to be conducted with a limited access drill rig.

In accordance with the QAPP, sample location identification codes are based on "970" for Building 970; "SB" for soil boring, "MW" for monitoring well; and sequential numbering starting at 101. Multiple samples could be collected from a single soil boring sample location (soil and/or grab groundwater); however, each sample of varying media from the same boring location will have the same sample location identifier. The media sampled will be marked on the chain of custody form and input into the media field in the Trust database when the data are uploaded. In keeping with the QAPP, a soil sample from 5 feet below ground surface will be designated as 970SB101[5].

For the proposed groundwater monitoring wells, the driller will drill 3 soil borings in the relatively flat areas which will be converted to 2-inch diameter groundwater monitoring wells if groundwater is encountered at less than 40 feet below ground surface. Soil samples will be collected at 5 foot intervals to log the soil and screen the soil with an OVM for volatile chemicals. If stained or odorous soil is encountered, soil samples will be collected at the bottom of the stained region, and also at 5 and 10 feet below the stained region. If groundwater is encountered in the borehole, the groundwater elevation will be measured, and a groundwater monitoring well will be installed with 2-inch diameter PVC piping. The groundwater elevation will be measured in the well after development, and the wells added to the Trust's groundwater monitoring program. If no groundwater is encountered and the depth of 40 ft bgs is reached, the boreholes will be left open a minimum of 12 hours to see if groundwater enters the hole. If no groundwater is found in the borehole after 12 hours, the hole will be grouted and no well installed.

The driller will also drill 4 soil borings up to 25 ft bgs to collect samples for the evaluation of lateral and vertical extent of petroleum impact. Soil samples will be collected at 5 foot intervals to log the soil and screen the soil with an OVM for volatile chemicals. If stained or odorous soil is encountered, soil samples will be collected at the bottom of the stained region, and also at 5 and 10 feet below the stained region. If no stained or odorous soil is encountered by 25 ft bgs (the anticipated limit of the planned equipment[2]), the soil samples collected at 5, 10, and 15 ft bgs will be analyzed. If groundwater is encountered in the borehole, the depth to groundwater will be measured, a grab groundwater sample will be collected, and the borehole will be terminated.

The proposed sample identification numbers, depths, and corresponding laboratory analyses are summarized in Table 2. As noted in Table 2, the actual sample number and depth may change based on field conditions encountered.

[2] The soil borings between Former AST 970 and Andrews Road (Figure 3) are assumed to be drilled with a limited access drill rig, which has a limited depth capacity.

The soil samples will be analyzed by Curtis & Tompkins Ltd., a State-certified analytical laboratory, on a standard turnaround time. EKI anticipates that Curtis & Tompkins will analyze approximately 16 soil samples and 3 groundwater samples, as described above, and 6 QA/QC samples to be collected in accordance with the QAPP, as described below.

3.3 Field Quality Control Samples

Field duplicates will be collected as part of this investigation. A field duplicate is a sample collected at the same time, and from the same source and depth as the associated primary sample. Field duplicate pairs are collected to assess the consistency or precision of the laboratory's analytical system. The QAPP specifies a frequency of 10% for field duplicates; therefore, two field duplicate soil samples and one field duplicate groundwater sample will be collected and submitted to the laboratory for analysis. If reusable sampling equipment is decontaminated and reused, an equipment rinseate blank will be collected and analyzed for each day of sampling.

3.4 Post-Sample Collection Activities

After completion of the soil sampling, a State of California-licensed land surveyor will survey the sampling locations. EKI has assumed that PLS Surveys, Inc. of Alameda, California will perform the surveying under the direction of EKI. The surveyor will report the survey coordinates in both NAVD88 and PLLW survey datums, as well as identify the control points used to prepare the survey.

Drill cuttings and decontamination rinse water from the investigation will be drummed and sampled for characterization and appropriate disposal. Other anticipated investigation-derived waste includes containers of plastic bags with used personal protective equipment and non-hazardous trash. The non-hazardous trash will be disposed with Trust municipal trash. Disposal of all wastes will be the responsibility of the Trust.

4.0 ANALYTICAL METHODS

Analytical methods proposed for soil and groundwater samples include the following:

- TPH as diesel (carbon range C12 - C24) with silica gel cleanup by EPA Method 8015 modified;

- TPH as fuel oil (carbon range C24 - C36) by EPA Method 8015 modified; and

- PAHs by EPA Method 8270C.

The analytical quality control criteria are provided in the QAPP. Analytical data will be validated by DataVal, Inc. of Novato, California.

5.0 SCHEDULE

Field work activities will commence upon stakeholder approval of this Field Sampling Plan. It is anticipated that the drilling and soil and groundwater sampling activities will be completed in approximately two weeks. A sampling report will be prepared after receipt of the validated analytical data.

6.0 REFERENCES

Erler & Kalinowski, Inc. ("EKI"), 2002. Development of Presidio-Wide Cleanup Levels for Soil, Sediment, Groundwater and Surface Water, Presidio of San Francisco, California. October, as revised in May 2006.

International Technology Corporation ("IT"), 1998. *Presidio Petroleum Tank Closure and Recommended Site Action Report, Presidio Fuel Tank Removal Program, Presidio of San Francisco, Volume 1, November*.

Tetra Tech, 2001. *Presidio-Wide Quality Assurance Project Plan, Sampling and Analysis Plan, Presidio of San Francisco, San Francisco, California*. April.

Regional Water Quality Control Board, San Francisco Bay Region, *Site Cleanup Requirements, Presidio of San Francisco, California*, Order R2-2003-0080.

TABLE 1 - BUILDING 970/971 DATA QUALITY OBJECTIVES

Presidio of San Francisco, California

State the Problem	Identify the Decisions	Identify Inputs to the Decisions	Define the Study Boundaries	Develop Decision Rules	Specify Limits on Decision Errors	Optimize the Design
	Groundwater Characterization					
Soil located along fuel distribution system ("FDS") pipeline section MT-2, immediately north of aboveground storage tank ("AST") 970 ("Site"), was found to contain soil with petroleum hydrocarbons as diesel ("TPHd") and fuel oil ("TPHfo") as well polycyclic aromatic hydrocarbons ("PAHs") above applicable soil cleanup levels. Affected soil was excavated by the Army to the top of the competent serpentine bedrock, to a depth approximately 13.5 ft bgs. However, soil potentially above applicable cleanup levels was found to extend to a maximum depth of 21.5 ft below the original ground surface in one of four tests pits dug at the bottom of excavation, in the bedrock. Additionally, no groundwater data have been collected at the Site. The objective of this sampling program is to further evaluate the lateral and vertical extent of soil above applicable cleanup levels at the Site as well as to evaluate potential groundwater impacts.	1. What is the depth to groundwater at the Site? 2. If groundwater at the Site is < 40 ft bgs, what is the groundwater flow direction at the Site? 3. Is groundwater at the Site affected with TPH or PAHs above applicable cleanup levels? 4. If groundwater at the Site is affected with TPH or PAHs above cleanup levels, how do the concentrations of these chemicals change over time?	1. Presence of water and water level measurements in boreholes and wells. 2. Results of chemical analysis from groundwater samples. 3. Comparison of analytical results to applicable cleanup levels.	The groundwater investigation will be conducted immediately adjacent to the former excavation north of AST 970.	1. If stained or odorous soil is encountered while sampling soil at soil boreholes drilled as potential groundwater monitoring wells, collect soil samples for chemical analysis. 2. If groundwater is encountered at < 40 ft bgs in soil boreholes, measure water levels in the boreholes and complete boreholes as groundwater monitoring wells. Develop monitoring wells, re-measure groundwater levels, and collect groundwater samples for each well. 3. If groundwater monitoring wells are installed, wells will be included in the Presidio-wide groundwater monitoring program. 4. If no groundwater is encountered at < 40 ft bgs in soil boreholes, allow a minimum of 12 hours for groundwater to come into the hole.[1] 5. If no water is present in borehole after 12 hours, grout borehole. 6. If groundwater at the Site is found to contain TPH or PAHs above cleanup levels, monitor groundwater and assess if additional remediation action is warranted.	Field, analytical, and data validation procedures will follow the QAPP (Tetra Tech, 2001). Duplicate samples (groundwater) will also be collected per the QAPP.	1. Wells locations have been placed in triangular configuration to obtain groundwater gradient information. Two wells will be installed in the presumed downgradient direction and one in the presumed upgradient direction from the impacted area. 2. Soil samples will be collected from the borehole from 970MW101 to evaluate if TPH concentrations detected in former trenches is impacting groundwater. 3. A limited-access hollow-stem auger drill rig will be used to install three, 6-inch diameter soil boreholes to a depth of 40 ft bgs. 4. Soil sampling will be conducted at 5 foot intervals in each soil borehole for soil logging purposes and for screening with an OVM. 5. Soil samples for chemical analysis due to stained or odorous soil will be collected at the maximum depth of the stained region and 5 and 10 feet below the stained region. Samples will be submitted for chemical analysis of TPHd and TPHfo by United States Environmental Protection Agency ("US EPA") Method 8015M, and PAHs by US EPA Method 8270C. 6. The water level in the borehole and subsequently in the developed monitoring well will be measured using a water level probe. 7. If groundwater is present in the borehole, groundwater monitoring wells will be constructed using 2-inch diameter PVC piping, No. #2/16 sand. 8. If boreholes are not completed as wells, boreholes will be grouted using Portland cement. 9. Soil borehole or monitoring well locations will be surveyed.
	Soil Characterization					
	What is the lateral and vertical extent of soil with petroleum hydrocarbons or PAHs present above cleanup levels at the Site?	1. Results of previous chemical analysis of soil samples. 2. Results of chemical analysis of soil samples from soil boreholes. 3. Comparison of analytical results to applicable cleanup levels.	The study boundaries are defined by Andrews Road to the north and confirmation soil samples reported to be below applicable cleanup levels to the south and along most of the eastern edge of the excavation. The site boundaries to the west are undefined, as soil was found to be above cleanup levels at several locations on the western edge of the former excavation.	1. If stained or odorous soil is encountered, collect soil samples at the maximum depth of the stained region and 5 and 10 feet below the stained region. 2. If the water table is encountered, a grab groundwater sample will be collected and the borehole will be terminated. The maximum depth of a borehole will not exceed 25 ft due to equipment limitations. 3. If no stained soil or odorous soil is encountered, collect soil samples at approximately 5, 10, and 15 ft bgs. 4. Once the soil analytical data are received from the laboratory, assess if additional remediation action is warranted.	Field, analytical, and data validation procedures will follow the QAPP (Tetra Tech, 2001). Duplicate samples (soil) will also be collected per the QAPP.	1. Boring locations have been placed 5 to 10 feet from prior locations where TPH or PAHs were above cleanup levels, or where no previous samples had been collected, outside the prior excavation area. 2. A portable drill rig will be used to drill four 4-inch diameter soil boreholes to a depth of 20 ft bgs. 3. Soil sampling will be conducted at 5-foot intervals for soil logging purposes and for soil screening using an OVM. 4. Soil samples collected for chemical analyses will be analyzed for TPHd and TPHfo by US EPA Method 8015M and for PAHs by US EPA Method 8270C. 5. Soil borehole locations will be surveyed.

Abbreviations:

<	less than	OVM	organic vapor meter
AST	aboveground storage tank	PAHs	polycyclic aromatic hydrocarbons
bgs	below ground surface	PVC	polyvinyl chloride
FDS	Fuel Distribution System	QAPP	*Presidio-Wide Quality Assurance Project Plan, Sampling and Analysis Plan*, Tetra Tech EM Inc., dated April 2001.
ft	feet	TPHd	total petroleum hydrocarbons as diesel
Mini-CAP	Mini-Corrective Action Plan	TPHfo	total petroleum hydrocarbons as fuel oil
		US EPA	United States Environmental Protection Agency

References:

International Technology Corporation ("IT"), 1998. *Petroleum Tank Closure and Recommended Site Action Report, Presidio Fuel Tank Removal Program, The Presidio of San Francisco, California*. November.

IT Corporation, 1999. *Fuel Distribution System Closure Report*, Presidio of San Francisco, California. May.

[1] The permeability of serpentine bedrock is low and additional time may be required to allow groundwater levels within boreholes to equilibrate with the potentiometric surface at the Site.

Table 2
Soil and Groundwater Sample Laboratory Analysis Matrix
for the AST 970, Building 971 Field Sampling Plan

Presidio of San Francisco, California

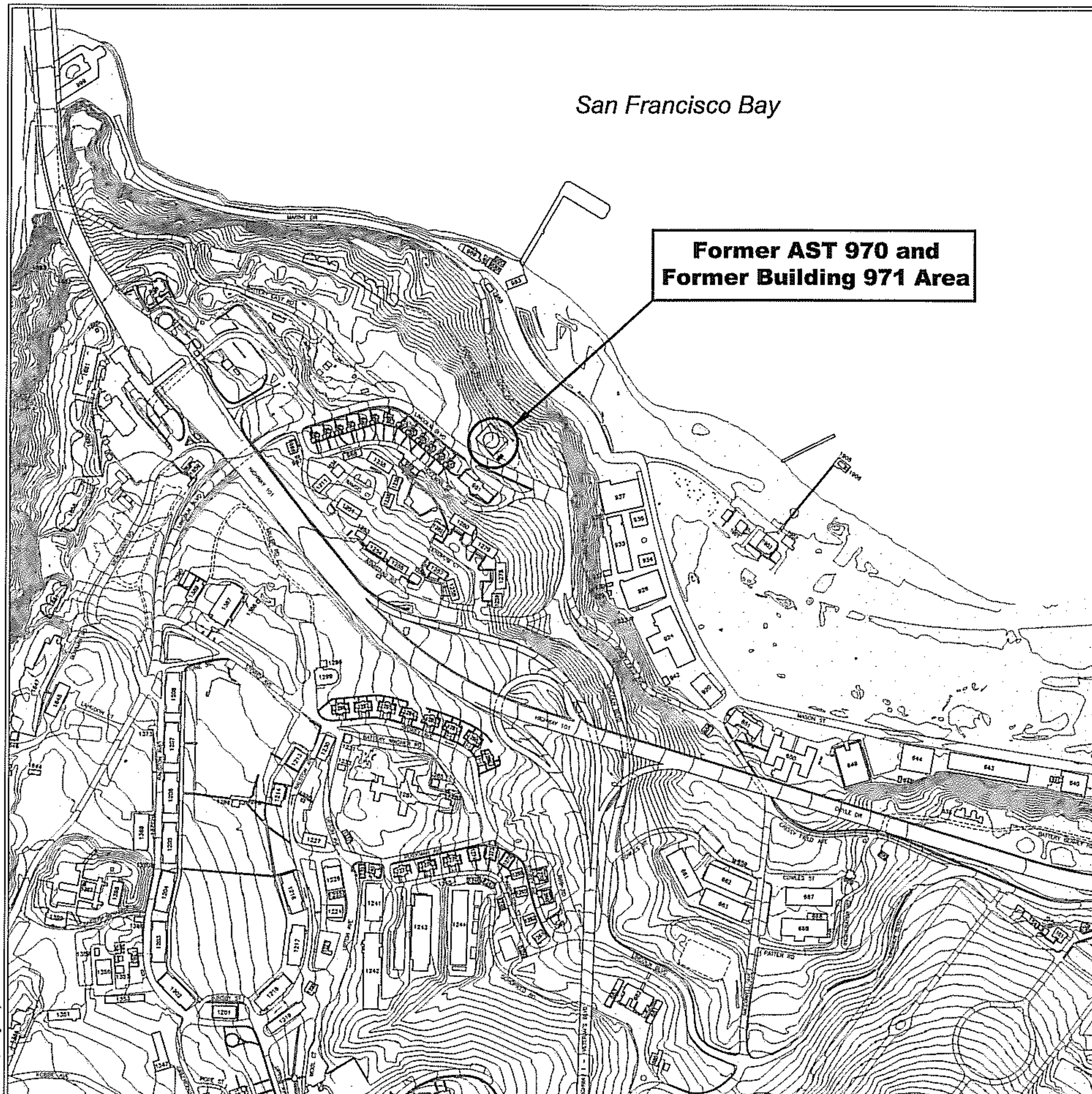
Sample ID (note 1)	Sample Depth (ft bgs) (note 1)	Matrix	Laboratory Analyses TPH-d (EPA 8015m)	TPH-fo (EPA 8015m)	PAHs (EPA 8270C)
Groundwater Characterization					
970MW101(5)	5	soil	*	*	*
970MW101(10)	10	soil	*	*	*
970MW101(15)	15	soil	*	*	*
970MW101(20)	20	soil	*	*	*
970MW101 (note 3)	--	water	*	*	*
970MW102 (note 3)	--	water	*	*	*
970MW103 (note 3)	--	water	*	*	*
Soil Characterization					
970SB101(5)	5	soil	*	*	*
970SB101(10)	10	soil	*	*	*
970SB101(15)	15	soil	*	*	*
970SB102(5)	5	soil	*	*	*
970SB102(10)	10	soil	*	*	*
970SB102(15)	15	soil	*	*	*
970SB103(5)	5	soil	*	*	*
970SB103(10)	10	soil	*	*	*
970SB103(15)	15	soil	*	*	*
970SB104(5)	5	soil	*	*	*
970SB104(10)	10	soil	*	*	*
970SB104(15)	15	soil	*	*	*

Abbreviations:

-- – not applicable
BTEX – benzene, toluene, ethylbenzene, and total xylenes
ft bgs – feet below ground surface
LUFT – leaking underground fuel tank
MS/MSD – matrix spike/ matrix spike duplicate
PAHs – polycyclic aromatic hydrocarbons
QAPP – *Presidio-Wide Quality Assurance Project Plan, Sampling and Analysis Plan,* Tetra Tech EM Inc., dated April 2001.
TPHd – total petroleum hydrocarbons as diesel
TPHfo – total petroleum hydrocarbons as fuel oil
US EPA – United States Environmental Protection Agency

Notes:

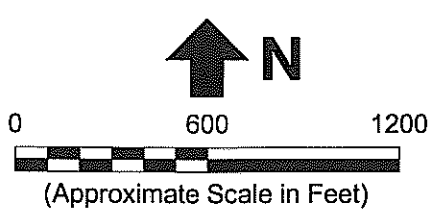
(1) Proposed soil sample number and sample depths may be modified if stained or odorous soil is encountered in the field.
(2) Per QAPP guidance, one duplicate will be collected for every ten samples on each day of the field work. Duplicate samples will be noted with "DUP" in the Sample ID.
(3) Groundwater samples will be collected from groundwater monitoring wells if depth to groundwater is < 40 ft bgs at the Site. If depth to water is > 40 ft bgs, no groundwater samples will be collected.
(4) Proposed soil and groundwater samples will be analyzed on a ten day turnaround time by by either Severn-Trent Laboratories - San Francisco of Pleasanton, California or Curtis & Tompkins of Berkeley, California.
(5) Soil and water samples will be collected for disposal characterization purposes and analyzed for TPHd by US EPA Method 8015M, TPHfo by US EPA Method 8015M, LUFT 5 metals by US EPA Method 6010B, and BTEX by US EPA Method 8021. Soil sample IDs will be provided by the Trust.



Reference: Basemap source: Presidio Trust, 2006.

Note:

1. All locations are approximate.



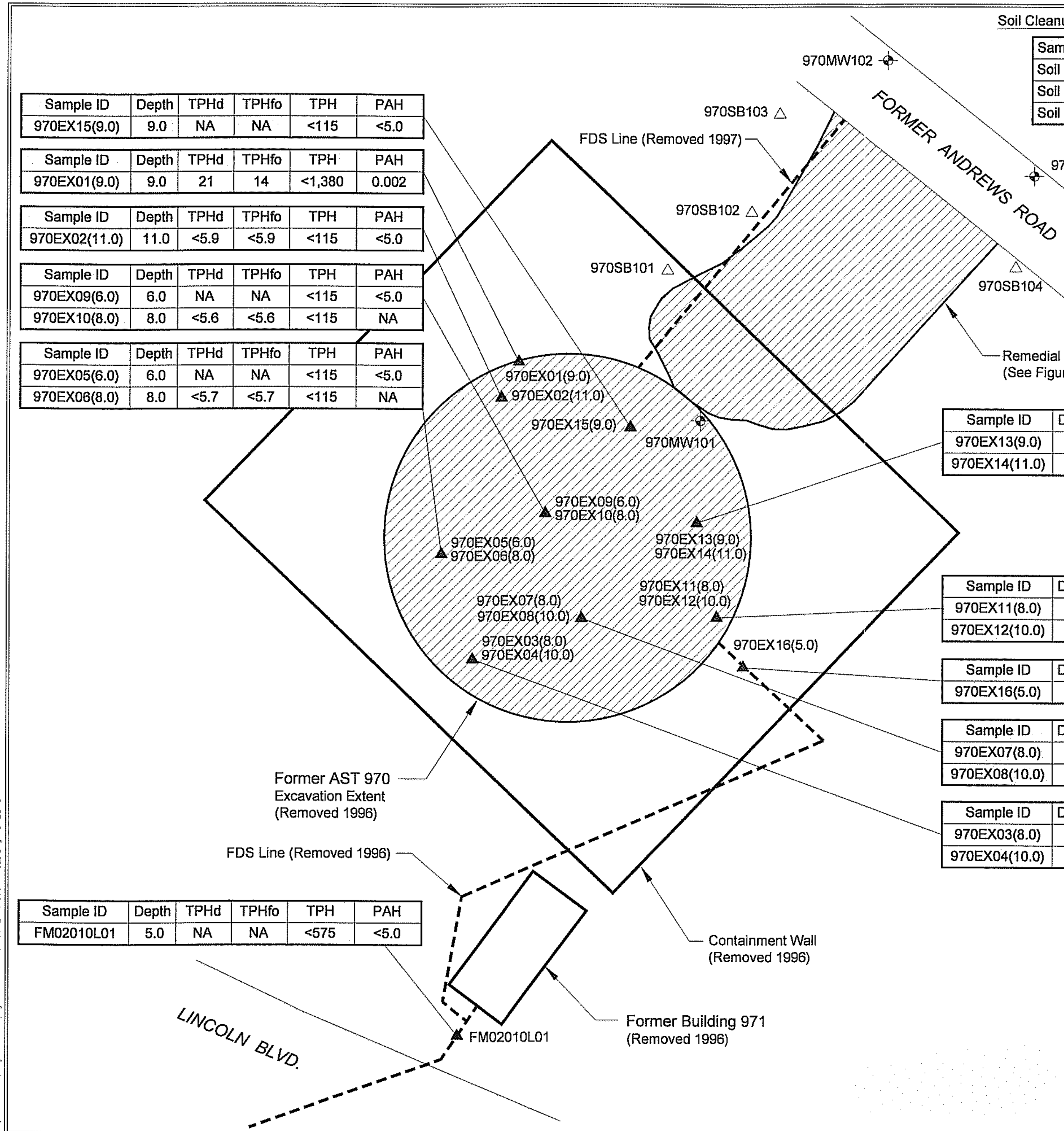
Erler & Kalinowski, Inc.

Site Location Map

Former AST 970 and Former Building 971 Area
The Presidio Trust
San Francisco, CA
March 2007
EKI A70004.17

Figure 1

20070314.11454462 G:\A70004.17\Bldg 970 971\Figure 01 - Site Location Map.dwg Layout1



Soil Cleanup Levels (Water Board Order R2-2003-0080):

Sample Depth	CUL	TPHd	TPHfo
Soil 0 to 3 ft bgs	Eco-T	700	980
Soil 3 to 10 ft bgs	HH-Res	1,380	1,900
Soil > 10 ft bgs	>5GW	15,000	15,000

Sample ID	Depth	TPHd	TPHfo	TPH	PAH
970EX15(9.0)	9.0	NA	NA	<115	<5.0

Sample ID	Depth	TPHd	TPHfo	TPH	PAH
970EX01(9.0)	9.0	21	14	<1,380	0.002

Sample ID	Depth	TPHd	TPHfo	TPH	PAH
970EX02(11.0)	11.0	<5.9	<5.9	<115	<5.0

Sample ID	Depth	TPHd	TPHfo	TPH	PAH
970EX09(6.0)	6.0	NA	NA	<115	<5.0
970EX10(8.0)	8.0	<5.6	<5.6	<115	NA

Sample ID	Depth	TPHd	TPHfo	TPH	PAH
970EX05(6.0)	6.0	NA	NA	<115	<5.0
970EX06(8.0)	8.0	<5.7	<5.7	<115	NA

Sample ID	Depth	TPHd	TPHfo	TPH	PAH
970EX13(9.0)	9.0	NA	NA	<115	<5.0
970EX14(11.0)	11.0	<5.4	<5.4	<115	NA

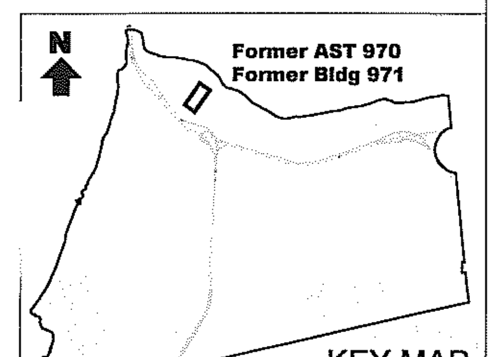
Sample ID	Depth	TPHd	TPHfo	TPH	PAH
970EX11(8.0)	8.0	NA	NA	<115	<5.0
970EX12(10.0)	10.0	48	46	<115	NA

Sample ID	Depth	TPHd	TPHfo	TPH	PAH
970EX16(5.0)	5.0	370	1,200	<115	<5.0

Sample ID	Depth	TPHd	TPHfo	TPH	PAH
970EX07(8.0)	8.0	NA	NA	<115	<5.0
970EX08(10.0)	10.0	<5.7	<5.7	<115	NA

Sample ID	Depth	TPHd	TPHfo	TPH	PAH
970EX03(8.0)	8.0	68	63	<575	<5.0
970EX04(10.0)	10.0	<5.9	<5.9	<115	NA

Sample ID	Depth	TPHd	TPHfo	TPH	PAH
FM02010L01	5.0	NA	NA	<575	<5.0



KEY MAP

Legend:

- ▲ Historical Soil Sampling Locations (1996)
- 970EX15(9.0) Soil Sample Identification Number and Depth in Feet
- Proposed Groundwater Monitoring Well Location
- △ Proposed Soil Borehole Location

Abbreviations:

<	= less than
>5GW	= soil cleanup level for protection of water quality assuming 5 feet above highest groundwater
AST	= above ground storage tank
CUL	= cleanup level
Eco-T	= Soil cleanup levels for the protection of ecological receptors
ft bgs	= feet below ground surface
HH-Res	= Soil cleanup levels for the protection of human health, residential receptors
mg/kg	= milligrams per kilogram
NA	= sample not analyzed
PAH	= polycyclic aromatic hydrocarbons
TPH	= total petroleum hydrocarbons measured by immunoassay analysis, and compared to TPHd cleanup levels
TPHd	= total petroleum hydrocarbons as diesel
TPHfo	= total petroleum as fuel oil

Notes:

1. All locations are approximate.
2. Basemap from Montgomery Watson, (Revised) Mini Corrective Action Plan, dated 1997.
3. All soil data reported as mg/kg, depths in feet below ground surface.
4. All 970 excavation samples collected on 22 October 1996.

Erler & Kalinowski, Inc.

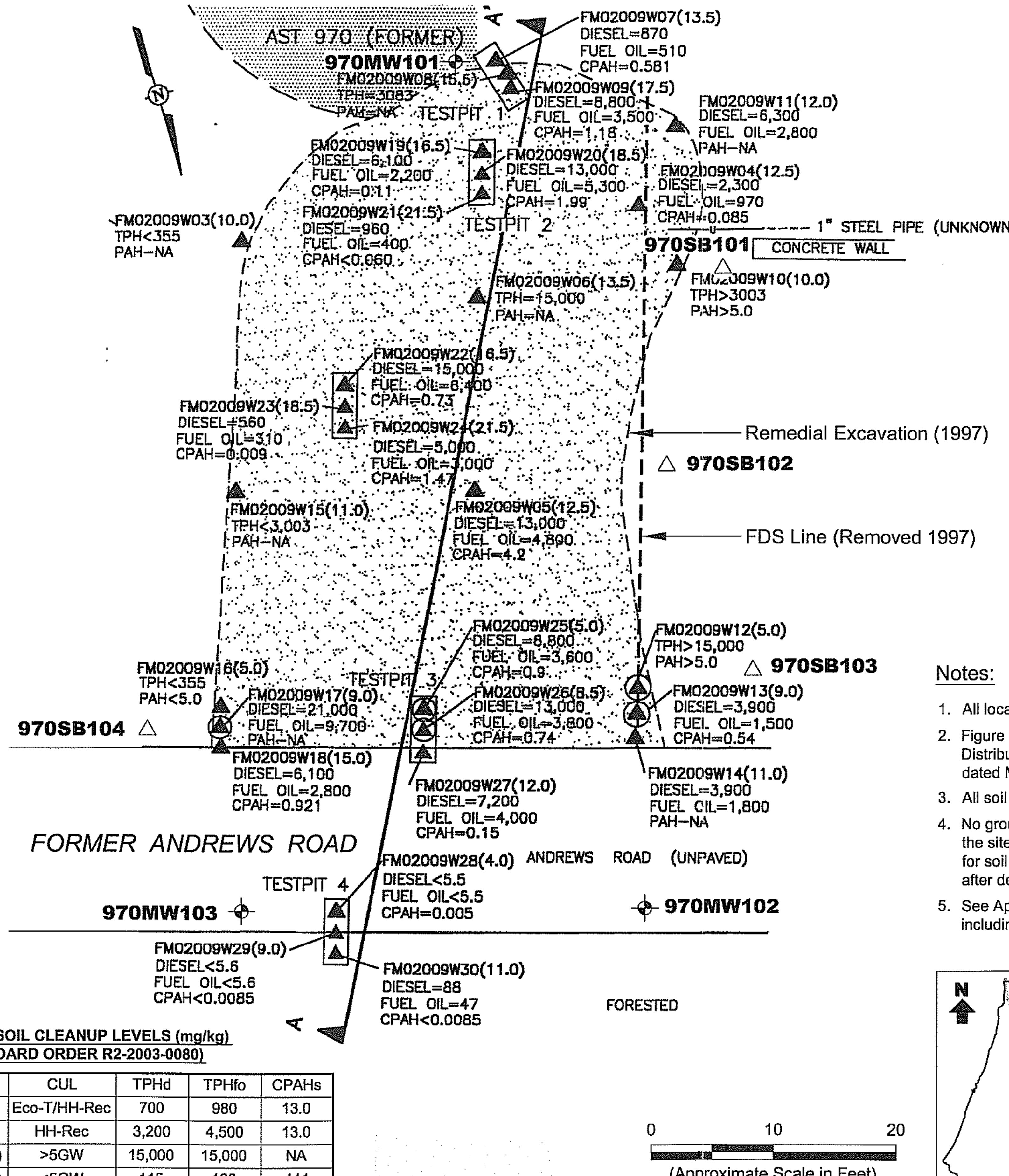
Historical Excavation Areas

Former AST 970 and Former Building 971 Area
Presidio Trust
San Francisco, CA

March 2007
EKI A70004.17

Figure 2

G:\A70004.17\Bldg 970 971\Figure 02 - Historical Excavation Areas.dwg 3-28-07

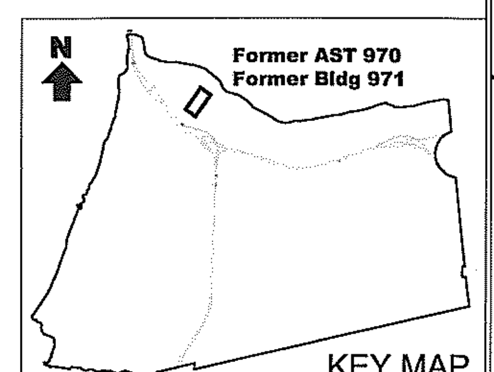


APPLICABLE SOIL CLEANUP LEVELS (mg/kg)
(WATER BOARD ORDER R2-2003-0080)

Sample Depth	CUL	TPHd	TPHfo	CPAHs
Soil 0 to 3 ft bgs	Eco-T/HH-Rec	700	980	13.0
Soil 3 to 10 ft bgs	HH-Rec	3,200	4,500	13.0
Soil >5 ft above GWT (Note 4)	>5GW	15,000	15,000	NA
Soil <5 ft above GWT (Note 4)	<5GW	115	160	111

Notes:

1. All locations are approximate.
2. Figure is adapted from IT, Fuel Distributed System Closure Report, dated May 1999.
3. All soil data reported as mg/kg.
4. No groundwater data are available at the site. Therefore, soil action levels for soil >10 ft bgs will be determined after depth to groundwater is obtained.
5. See Appendix A for original IT figure including Section A - A'.



Legend:

- ▲ Soil Sampling Locations (1997)
- FM02009W12(5.0) Soil Sample Identification Number and Depth in Feet
- Soil Analytical Results Above Soil Action Levels (1997)
- Proposed Groundwater Monitoring Well Location
- △ Proposed Soil Borehole Location

Abbreviations:

AST	above ground storage tank
<5GW	Soil Cleanup Levels for the Protection of Water Quality at Drinking Water Standards, <5 ft above the highest groundwater (Water Board Order R2-2003-0080, Table 4). Values are the same for the Coastal Bluff and the Marina Groundwater Basin
>5GW	Soil Cleanup Levels for the Protection of Water Quality at Drinking Water Standards, >5 ft above the highest groundwater (Water Board Order R2-2003-0080, Table 4). Values are the same for the Coastal Bluff and the Marina Groundwater Basin
CPAHs	total carcinogenic polycyclic aromatic hydrocarbons
CULs	applicable cleanup levels
DIESEL	total petroleum hydrocarbons as diesel
Eco-T	Soil cleanup levels for the protection of terrestrial ecological receptors
FDS	fuel distribution system
ft bgs	feet below ground surface
FUEL OIL	total petroleum hydrocarbons as fuel oil
GWT	groundwater table
HH-Rec	Soil cleanup levels for the protection of human health, recreational cleanup levels
IT	International Technology Corporation
mg/kg	milligrams per kilogram
NA	not applicable
PAH	polycyclic aromatic hydrocarbons
TPH	total petroleum hydrocarbons
TPHd	total petroleum hydrocarbons as diesel
TPHfo	total petroleum hydrocarbons as fuel oil

Erler & Kalinowski, Inc.

Proposed Soil and Grab Groundwater Sampling Locations with Selected Historical Soil Data

Former AST 970 and Former Building 971 Area

Presidio Trust
San Francisco, CA

March 2007
EKI A70004.17

Figure 3

G:\A70004.17\Bldg 970 971\Figure 03 - Proposed Soil and Grab GW Sampling.dwg 3-14-07

Appendix A

Table 7-5

from

Development of Presidio-Wide Cleanup Levels for Soil, Sediment, Groundwater and Surface Water, Presidio of San Francisco, California. **October 2002**

TABLE 7-5
HUMAN HEALTH AND ECOLOGICAL CLEANUP LEVELS FOR PETROLEUM HYDROCARBONS AND CONSTITUENTS IN SOIL AND SEDIMENT AT THE PRESIDIO OF SAN FRANCISCO

Presidio of San Francisco, California

Potential Chemical of Concern	Protection of Human Health			Protection of Ecological Receptors			Protection of Groundwater Resources: Cleanup Level for Soil to Maintain Drinking Water Standard in Groundwater		Protection of Groundwater Resources: Cleanup Level for Soil to Maintain Non-detectable Concentration in Groundwater in Lobos Creek Basin		Protection of Groundwater Resources: Cleanup Level for Soil at Crissy Field	
	Residential (mg/kg); (a)	Recreational (mg/kg); (a)	Maintenance (mg/kg); (a)	Terrestrial Receptors (mg/kg); (a)	Freshwater Aquatic Organisms (mg/kg); (b)	Saltwater Aquatic Organisms (mg/kg); (c)	Less than 5 feet Above Groundwater (mg/kg); (a)	Greater than 5 feet Above Groundwater (mg/kg); (a)	Less than 5 feet Above Groundwater (mg/kg); (a)	Greater than 5 feet Above Groundwater (mg/kg); (a)	Less than 5 feet Above Groundwater (mg/kg); (a)	Greater than 5 feet Above Groundwater (mg/kg); (a)
Inorganic Chemicals												
Lead	-	-	-	50 (d)	-	-	-	-	-	-	-	-
Semivolatile Organic Compounds												
Anthracene	5,900	13,800	17,800	-	-	-	308	-	0.05	-	1,120	-
Benzo(a)anthracene	0.43	1	1.5	-	-	-	8	-	0.2	-	23	-
Benzo(a)pyrene	0.04	0.1	0.15	0.3	-	-	3	-	0.8	-	9	-
Benzo(b)fluoranthene	0.43	1	1.5	-	-	-	23	-	0.6	-	64	-
Benzo(g,h,i)perylene	620	1,400	1,700	-	-	-	5,040	-	2	-	19,500	-
Benzo(k)fluoranthene	0.43	1	1.5	-	-	-	23	-	0.6	-	64	-
Chrysene	4.3	10	15	-	-	-	54	-	0.3	-	151	-
Fluoranthene	820	1,900	2,300	-	-	-	316	-	0.05	-	1,160	-
Fluorene	770	1,800	2,300	-	-	-	60	-	0.05	-	220	-
Naphthalene	480	1,100	2,300	-	-	-	9	-	0.05	-	140	-
Phenanthrene	600	1,400	1,700	-	-	-	86	-	0.05	-	410	-
Total Carcinogenic PAHs	5.6	13	19.7	-	-	-	111	-	2.5	-	253	-
Pyrene	620	1,400	1,700	-	-	-	241	-	0.09	-	910	-
Petroleum Hydrocarbons and Constituents												
TPH (as diesel); (e)	1,380	3,200	6,700	700	144 (f); (g)	144 (f)	115	15,000	7	15,000	1,950	15,000
TPH (as gasoline)	1,030	2,400	5,900	610	140	11.6	100	5,000	7	5,000	1,690	5,000
TPH (as fuel oil) (h)	1,900	4,500	9,400	980	144 (g)	144	160	15,000	10	15,000	2,730	15,000
Benzene	0.6	1.5	5	40	0.79	50	0.005	140	0.005	140	1	140
Ethylbenzene	840	1,900	6,600	125	15	5	13	60	0.009	60	19	60
Toluene	530	1,200	12,800	270	3	260	1	420	0.005	420	14	420
Total Xylenes	1,080	2,500	109,000	55	5.7	22	33	180	0.009	180	4,340	180

TABLE 7-5
HUMAN HEALTH AND ECOLOGICAL CLEANUP LEVELS FOR PETROLEUM HYDROCARBONS AND CONSTITUENTS IN SOIL AND SEDIMENT AT THE PRESIDIO OF SAN FRANCISCO

Presidio of San Francisco, California

Notes:

(a) Cleanup level values listed are obtained from Tables 1 through 5 of California Environmental Protection Agency, Regional Water Quality Control Board, San Francisco Bay Region Order No. 96-070, *Site Cleanup Requirements for the Cleanup of Petroleum Impacted Soils, U.S. Army, Presidio of San Francisco, California*, dated 15 May 1996.

(b) Cleanup level values listed are point-of-compliance concentrations for freshwater sediment obtained from Tables 5 and 6 of Montgomery Watson *Development of Point of Compliance Concentrations (POCCs) for Gasoline in Surface Waters and Sediments of the Proposed Freshwater Stream,* dated May 1999. Locations apply to Freshwater Ecological Protection Zones shown on Figure 7-2.

(c) Cleanup level values listed are point-of-compliance concentrations for saltwater sediment obtained from Table 16 of International Technology Corporation *Report of Petroleum Hydrocarbon Bioassay and Point-of-Compliance Concentration Determinations Saltwater Ecological Protection Zone, Presidio of San Francisco,* dated December 1997. Locations apply to Saltwater Ecological Protection Zones shown on Figure 7-2.

(d) According to Order No. 96-070, the value for lead applies only to cleanup of leaded gasoline releases and not from releases from other sources. Order No. 96-070 states that an alternative cleanup level can be derived for protection of ecological receptors from releases of lead other than leaded gasoline. Refer to Tables 7-2 through 7-4 for ecological cleanup level values that apply to releases of lead not from leaded gasoline.

(e) Total petroleum hydrocarbons ("TPH").

(f) Although value is derived for fuel oil, adoption of this cleanup level for TPH (as diesel) has been tentatively approved by RWQCB.

(g) Although value is derived for saltwater aquatic organisms, this cleanup level is also being used for freshwater organisms.

(h) These values also apply to TPH quantified as motor oil.

Appendix B

Selected Standard Operating Procedures

from

Presidio-Wide Quality Assurance Project Plan, Sampling and Analysis Plan. **April 2001**

SOP APPROVAL FORM

THE PRESIDIO TRUST
ENVIRONMENTAL STANDARD OPERATING PROCEDURE

SOIL SAMPLING

SOP NO. 001
REVISION NO. 00

Last Reviewed: December 2000

Quality Assurance Approved

12 JAN 01
Date

1.0 BACKGROUND

Soil sampling is conducted for three main reasons. First, samples can be obtained for laboratory chemical analysis. Second, samples can be obtained for laboratory physical analysis. Third, samples can be obtained for visual classification and field screening. These three sampling objectives can be achieved separately or in combination with each other. Sampling locations are typically chosen to provide chemical, physical, or visual information in both the horizontal and vertical directions. A sampling and analysis plan is used to outline sampling methods and provide preliminary rationale for sampling locations. Sampling locations may be adjusted in the field based on the screening methods being used and the physical features of the area.

1.1 PURPOSE

Soil sampling is conducted to determine the chemical, physical, and visual characteristics of surface and subsurface soils.

1.2 SCOPE

This standard operating procedure (SOP) describes procedures for soil sampling in different areas using various implements. It includes procedures for test pit, surface soil, and subsurface soil sampling, and describes eight devices. It also discusses procedures for collecting soil samples for volatile organic compound (VOC) analysis using the EnCore™ soil sampler system.

1.3 DEFINITIONS

Hand Auger: Instrument attached to the bottom of a length of pipe that has a crossarm or "T"-handle at the top. The auger can be closed-spiral or open-spiral.

Bucket Auger: A type of auger that consists of a cylindrical bucket 10 to 72 inches in diameter with teeth arranged at the bottom.

Core Sampler: Thin-wall cylindrical metal tube with diameter of 0.5 to 3 inches, a tapered nosepiece, a T-handle to facilitate sampler deployment and retrieval, and a check valve (flutter valve) in the headpiece.

Spatulas or Spoons: Stainless steel instruments for collecting loose unconsolidated material.

Trier: Tube cut in half lengthwise with a sharpened tip that allows for collection of sticky solids or loosening of cohesive soils.

Trowel: Tool with a scooped blade 4 to 8 inches long and 2 to 3 inches wide and has a handle.

Split-Spoon (or Split-Barrel) Sampler: Thick-walled steel tube that is split lengthwise. A cutting shoe is attached to the lower end; the upper end contains a check valve and is connected to drill rods.

Thin-Wall Tube Sampler: Steel tube (1 to 3 millimeters thick) with tapered bottom edge for cutting. The upper end is fastened to a check valve that is attached to drill rods.

1.4 REFERENCES

Barth, D.S., and B.J. Mason. 1984. "Soil Sampling Quality Assurance Users Guide." EPA 600/4-84-043.

DeVara, E.R., B.P. Simmons, R.D. Stephens, and D.L. Storm. 1980. "Samplers and Sampling Procedures for Hazardous Waste Streams." EPA 600/2-80-018. January.

Mason, B.J. 1983. "Preparation of Soil Sampling Protocol: Techniques and Strategies." EPA 600/4-83-020.

U.S. Environmental Protection Agency (EPA). 1987. "A Compendium of Superfund Field Operations Methods." Office of Solid Waste and Emergency Response Directive 9355.0-14 (EPA/540/P-87/001).

EPA. 1991. "Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells." EPA/600/4-89/034. March.

EPA. 1994. "Soil Sampling." Environmental Response Team SOP No. 2012. Revision No. 0.0. November 16. (On-Line Address: http://www.ert.org/media_resrcs/media_resrcs.asp.)

1.5 REQUIREMENTS AND RESOURCES

Soil sampling requires that one or more of the following types of equipment be used:

Sampling Equipment	Other Required Equipment
Spoons and spatulas	Sample containers, labels, and chain-of-custody forms
Trowel	Logbook
Shovel or spade	Measuring tape
Trier	Soil classification guidelines
Core sampler	Wax for sealing ends of thin-wall tube

Hand auger	Plastic sheeting
Bucket auger	Decontamination equipment
Split-spoon	Drilling equipment
Thin-wall tube	Backhoe
	Health and safety equipment

2.0 PROCEDURES

This SOP presents procedures for conducting test pit, surface soil, and subsurface soil sampling. The project-specific field sampling plan will specify which of the following procedures will be used.

Soil samples for chemical analysis should be collected in the following order: (1) VOCs, (2) semivolatile organic compounds, and (3) metals. Once the chemical samples have been containerized, samples for physical analyses can be containerized. Typical physical analyses conducted include (1) grain size distribution, (2) moisture content, (3) saturated permeability, (4) unsaturated permeability, and (5) Atterberg limits. Additionally, visual descriptions of samples, using the Unified Soil Classification System (USCS), should be recorded. Soil samples for chemical analyses can be collected either as grab samples or composite samples. A grab sample is collected from a discrete location or depth. A composite sample consists of soil combined from more than one discrete location. Typically, composite samples consist of soil obtained from several locations and homogenized in a stainless steel or Teflon® pan or tray. Samples for VOC analysis should not be composited.

2.1 TEST PIT SOIL SAMPLING

Test pit soil sampling is conducted when a complete soil profile is required or as a means of locating visually detectable contamination or sources, such as debris and underground storage tanks. This type of sampling provides a detailed description of the soil profile and allows for multiple samples to be collected from specific soil horizons. Before conducting any test pit or trench excavation with a backhoe, the sampling team should ensure that the sampling area is clear of utility lines, subsurface pipes, and poles. Any intrusive activities require Trust project review and permit issuance.

A test pit or trench is excavated by incrementally removing soil material with a backhoe bucket. The excavated soil may be placed on plastic sheeting (or other means of segregation), well away from the edge of the test pit. A test pit with depths greater than 4 feet must have its walls properly stabilized

according to Occupational Safety and Health Administration standards if personnel access to the pit is required. In many applications, sampling from the backhoe bucket will be preferred.

Personnel entering the test pit may be exposed to toxic or explosive gases and oxygen deficient environments. Air monitoring is required before entering the test pit and the use of appropriate respiratory gear and protective clothing is mandatory. At least two persons must be present at the test pit before sampling personnel enter the excavation and begin soil sampling.

Test pits are not practical for depths greater than 15 feet. If soil samples are required from depths greater than 15 feet, samples should be obtained using test borings instead of test pits. Test pits are also usually limited to a few feet below the water table. In some cases, a pumping system may be required to control the water level within the pits.

Access to open test pits should be restricted by use of flagging, tape, or fencing. If a fence is used, it should be erected at least 6 feet from the perimeter of the test pit. The test pit should be backfilled as soon as possible after sampling is completed.

Soil samples can be collected from the walls or bottom of a test pit using various equipment. A hand auger, bucket auger, or core sampler can be used to obtain samples from various depths. A trier, trowel, or spoons can be used to obtain samples from the walls or pit bottom surface.

2.2 SURFACE SOIL SAMPLING

The surface (and near surface) soil sampling equipment presented in this SOP is best suited for sampling to depths of 0 to 6 feet below ground surface (bgs). The sample depth, sample analyses, soil type, and soil moisture will also dictate the best-suited sampling equipment. Before sample collection, the sampling locations should be cleared of any surface debris such as twigs, rocks, and litter. The following table presents various surface soil sampling equipment and their effective depth ranges, operating means (manual or power), and sample types collected (disturbed or undisturbed).

Sampling Equipment	Effective Depth Range (feet bgs)	Operating Means	Sample Type
Hand Auger	0 to 6	Manual	Disturbed
Bucket Auger	0 to 4	Power	Disturbed
Core Sampler	0 to 4	Manual or Power	Undisturbed

Shovel	0 to 6	Manual	Disturbed
Trier	0 to 1	Manual	Disturbed
Trowel	0 to 1	Manual	Disturbed
Spoon/Spatula	0 to 0.5	Manual	Disturbed

The procedures for using these various types of sampling equipment are discussed below.

2.2.1 Hand Auger

A hand auger equipped with extensions and a T-handle is used to obtain samples from a depth of up to 6 feet below ground surface. If necessary, a shovel may be used to excavate the topsoil to reach the desired subsoil level. If topsoil is removed, its thickness should be recorded. Samples obtained using a hand auger are disturbed in their collection; determining the exact depth at which samples are obtained is difficult.

The hand auger is screwed into the soil at an angle of 45 to 90 degrees from horizontal. When the entire auger blade has penetrated soil, the auger is removed from the soil by lifting it straight up without turning it, if possible. If the desired sampling depth has not been reached, the soil is removed from the auger and deposited onto plastic sheeting. This procedure is repeated until the desired depth is reached and the soil sample is obtained. The auger is then removed from the boring and the soil sample is collected directly from the auger into an appropriate sample container.

2.2.2 Bucket Auger

A bucket auger, equipped similarly as the hand auger, is used to obtain disturbed samples from a depth of up to 4 feet. A bucket auger should be used when sampling stony or dense soil that prohibits the use of a hand-operated core or screw auger. A bucket auger with closed blades is used in soil that cannot generally be penetrated or retrieved by a core sampler.

The bucket auger is rotated while downward pressure is exerted until the bucket is full. The bucket is then removed from the boring, the collected soil is placed on plastic sheeting, and this procedure is repeated until the appropriate depth is reached and a sample is obtained. The bucket is then removed from the boring and the soil sample is transferred from the bucket to an appropriate sample container.

2.2.3 Core Sampler

A hand-operated core sampler (Figure 1), similarly equipped as the hand auger, is used to obtain samples from a depth of up to 4 feet in uncompacted soil. The core sampler is capable of retrieving undisturbed soil samples and is appropriate when low concentrations of metals or organics are of concern. The core sampler should be constructed of stainless steel. A polypropylene core sampler is generally not suitable for sampling dense soils or sampling at an appreciable depth.

The core sampler is pressed into the soil at an angle of 45 to 90 degrees from horizontal and is rotated when the desired depth is reached. The core is then removed, and the sample is placed into an appropriate sample container.

2.2.4 Shovel

A shovel may be used to obtain large quantities of soil that are not readily obtained with a trowel but is not recommended. A shovel is used when soil samples from a depth of up to 6 feet are to be collected by hand excavation; a tiling spade (sharpshooter) is recommended for excavation and sampling. A standard steel shovel may be used for excavation; either a stainless steel or polypropylene shovel may be used for sampling. Soil excavated from above the desired sampling depth should be stockpiled on plastic sheeting. Soil samples should be collected from the shovel and placed into the sample container using a stainless-steel scoop, plastic spoon, or other appropriate tool.

2.2.5 Trier

A trier (Figure 2) is used to sample soil from a depth of up to 1 foot. A trier should be made of stainless steel or polypropylene. A chrome-plated steel trier may be suitable when samples are to be analyzed for organics and heavy metal content is not a concern.

Samples are obtained by inserting the trier into soil at an angle of up to 45 degrees from horizontal. The trier is rotated to cut a core and is then pulled from the soil being sampled. The sample is then transferred to an appropriate sample container.

2.2.6 Trowel

A trowel is used to obtain surface soil samples that do not require excavation beyond a depth of 1 foot. A trowel may also be used to collect soil subsamples from profiles exposed in test pits. Use of a trowel is practical when sample volumes of approximately 1 pint (0.5 liter) or less are to be obtained. Excess soil should be placed on plastic sheeting until sampling is completed. A trowel should be made of stainless steel (or galvanized steel for samples that are analyzed for metals). It can be purchased from a hardware or garden store. Soil samples to be analyzed for organics should be collected using a stainless steel trowel. Samples may be placed directly from the trowel into sample containers.

2.3 SUBSURFACE SOIL SAMPLING

Subsurface soil sampling, in conjunction with borehole drilling, is required for soil sampling from depths greater than approximately 6 feet. Subsurface soil sampling is frequently coupled with exploratory boreholes or monitoring well installation. Refer to SOP No. 004 for monitoring well installation and borehole drilling procedures. Prior to intrusive soil sampling activities, site utilities may be required to be cleared by a qualified utility locator. As noted previously, intrusive soil activities also require Trust project review and permit issuance.

Subsurface soil sampling may be conducted using a drilling rig or power auger. Selection of sampling equipment depends upon geologic conditions and the scope of the sampling program. Two types of samplers used with machine-driven augers—the split-spoon sampler and the thin-wall tube sampler—are discussed below. All sampling tools should be cleaned before and after each use in accordance with SOP No. 014 (General Equipment Decontamination). Both the split-spoon sampler and the thin-wall tube sampler can be used to collect undisturbed samples from unconsolidated soils. Direct-push methods are commonly used to drive tube samplers equipped with acetate or brass sleeves. Acetate sleeves permit the recovery of a continuous core (typically 4-foot lengths) that can be divided for chemical or other analyses. The procedures for using the split-spoon and thin-wall tube samplers are presented below.

2.3.1 Split-Spoon Sampler

Split-spoon samplers are available in a variety of types and sizes. Site conditions and project needs (such as large sample volume for multiple analyses) determine the specific type of split-spoon sampler to be used. Figure 3 shows a generic split-spoon sampler.

The split-spoon sampler is advanced into the undisturbed soil beneath the bottom of the casing or borehole using a weighted hammer and a drill rod. The relationship between hammer weight, hammer drop, and number of blows required to advance the split-spoon sampler in 6-inch increments indicates the density or consistency of the subsurface soil. After the split-spoon sampler has been driven to its intended depth, it should be removed carefully to avoid loss of sample material. In noncohesive or saturated soil, a catcher or basket should be used to help retain the sample.

After the split-spoon sampler is removed from the casing, it is detached from the drill rod and opened. If VOC samples are to be collected, EnCore™ samplers should be filled with soil taken directly from the split-spoon sampler (see Section 2.4). Samples for other specific chemical analyses should be taken as soon as the VOC sample has been collected. The remainder of the recovered soil can then be used for visual classification of the sample and containerized for physical analysis. The entire sample (except for the top several inches of possibly disturbed material) is retained for analysis or disposal.

2.3.2 Thin-Wall Tube Sampler

A thin-wall tube sampler, sometimes called the Shelby tube (Figure 4), may be pressed or driven into soil inside a hollow-stem auger flight, wash bore casing, or uncased borehole. The tube sampler is pressed into the soil without rotation to the desired depth or until refusal. If the tube cannot be advanced by pushing, it may be necessary to drive it into the soil without rotation using a hammer and drill rod. The tube sampler is then rotated to collect the sample from the soil and removed from the borehole.

After removal of the tube sampler from the drilling equipment, the tube sampler should be inspected for adequate sample recovery. The sampling procedure should be repeated until an adequate soil core is obtained (if sample material can be retained by the tube sampler). The soil core obtained should be documented in the logbook. Any disturbed soil is removed from each end of the tube sampler. If chemical analysis is required, VOC samples must be collected immediately after the tube sampler is withdrawn (see Section 2.4). Before use, and during storage and transport, the tube sampler should be capped with a nonreactive material. For physical sampling parameters, the tube sampler should be sealed by pouring three 0.25-inch layers of sealing liquid (such as wax) in each end, allowing each layer to solidify before applying the next. The remaining space at each end of the tube is filled with Ottawa sand or other, similar sand, which is allowed to settle and compact. Plastic caps are then taped over the ends of the tube. The top and bottom of the tube sampler should be labeled and the tube sampler should be stored accordingly.

2.4 ENCORE™ SOIL SAMPLER SYSTEM FOR VOC ANALYSES

The EnCore™ soil sampler system is a dedicated system designed to collect, store, and deliver an approximately 5- or 25-gram soil sample in a zero-headspace container. The samplers are applicable to the collection of samples for VOC analyses (including chlorinated and aromatic VOCs and purgeable total petroleum hydrocarbons). No preservation chemicals are needed in the field. Extrusion and extraction of the whole sample in the sampler is done in the laboratory. No subsampling of the individual container is necessary. The EnCore™ sampler is a single use device and cannot be cleaned or reused. The EnCore™ system consists of the following four components:

- A cartridge with moveable plunger
- A cap with two locking arms
- A T-handle to aid in sampling
- An extrusion handle used in the laboratory

The soil collected in the EnCore™ sampler is stored in a sealed, headspace-free state. Three Viton "O"-rings achieve the seals (two located on the plunger and one on the cap of the sampler). For correct sealing, these O-rings must not be removed or disturbed.

The following procedures should be followed to collect a soil sample with the EnCore™ sampler:

- Before collecting the sample, hold the coring body and push the plunger rod down until small rod rests against the tabs (to ensure that the plunger moves freely). Then, depress locking lever on T-handle and place the coring body, plunger end first, into the open end of the T-handle, aligning the two slots on the coring body with the two locking pins in the T-handle. Twist the coring body clockwise to lock the pins in the slot. Check to ensure sampler is locked in place.

- Turn the T-handle such that the "T" is up and the coring body is down. This position leaves the plunger body flush with the bottom of the coring body. Holding the T-handle, push and twist the sampler into the soil until the coring body is completely full. When the sampler is full, the small O-ring on the plunger rod will be centered in the T-handle viewing hole (the upper hole for the 25-gram sampler and the lower hole for the 5-gram sampler). Remove the sampler from the soil.

- Before capping the sampler, wipe excess soil from the coring body exterior, ridge area, and any soil that may protrude beyond the opening end of the coring body to ensure proper sealing. Cap the coring body while it is still on the T-handle. Continue as above until three samples have been collected from the location. If only VOCs are to be analyzed for a given location, a small jar (minimum 2 ounce) of sample must be collected to allow for moisture content analysis.

When sampling surface soils, apply the EnCore™ sampler to a freshly exposed soil surface, following the procedures described above. When sampling subsurface soils, EnCore™ samples should be collected from one of the open ends of a sleeve core immediately upon retrieval.

The EnCore™ sampling system cannot be reliably used as stated above to sample sand, loose soil, or sediment since a cohesive plug will not be formed with these materials. When working with these soils, pull the plunger all the way back and lock it. Turn the sampler upside down and scoop the material into the coring body and cap it. Make a note of this method deviation in the field notebook.

Place the three collocated samples for each VOC analysis into one zipper bag. Seal the bag, place it into a prechilled cooler maintained at 4°C, and ship the samples to the laboratory for preservation and analysis. The recommended holding time between sampling and preservation by the laboratory is 48 hours. The recommended holding time between preservation and analysis is 14 days. The laboratory will preserve two EnCore™ containers using sodium bisulfate and one container using methanol. This allows for both low-level and high-level analysis of the sample.

FIGURE 1

HAND-OPERATED CORE SAMPLER

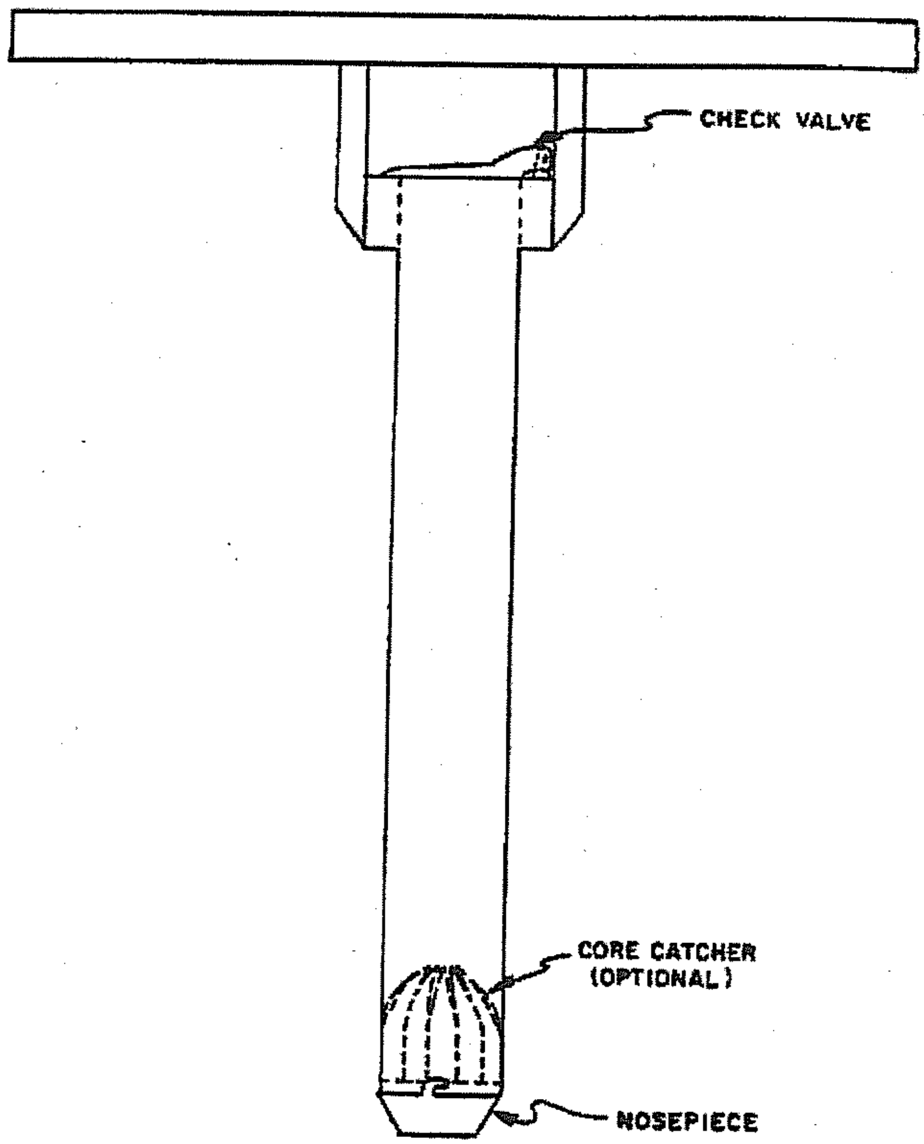


FIGURE 2

TRIER

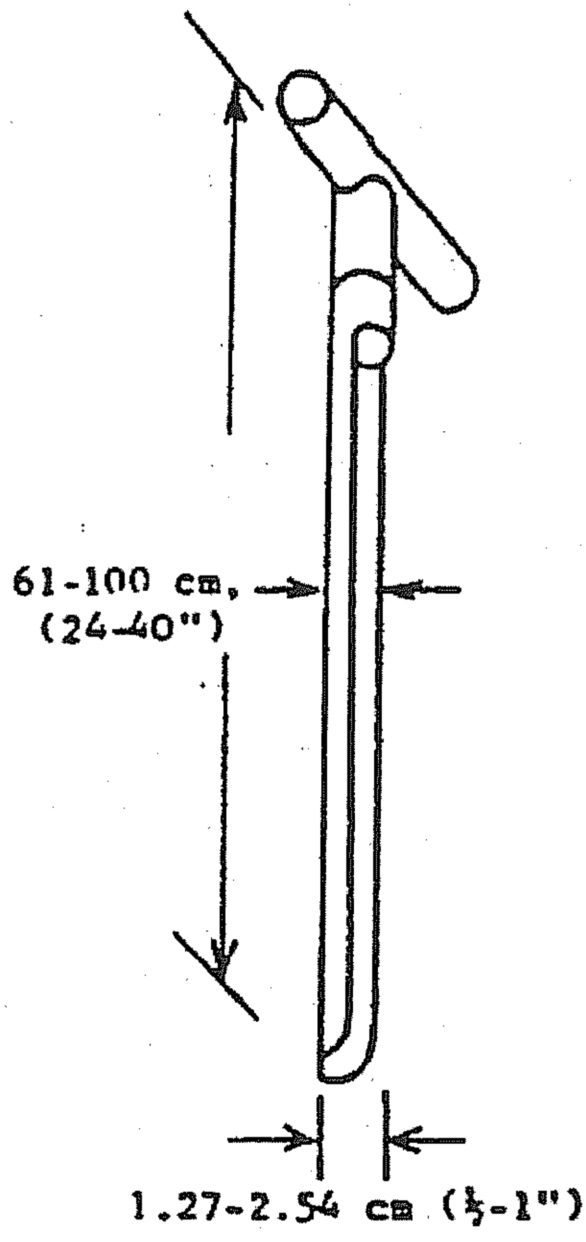


FIGURE 3

GENERIC SPLIT-SPOON SAMPLER

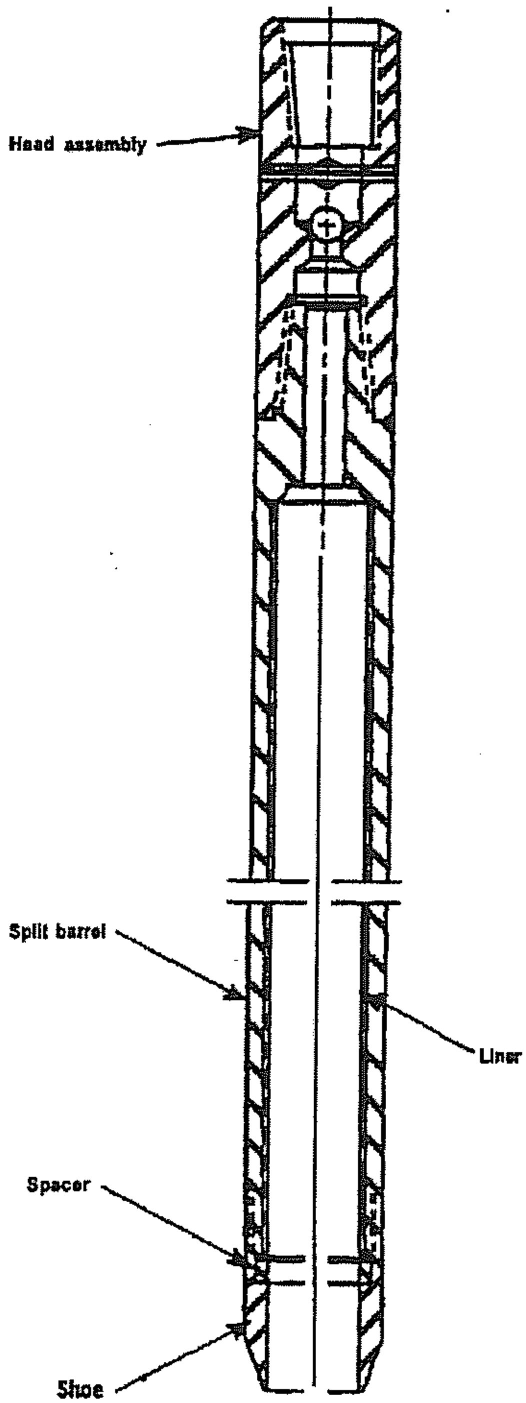
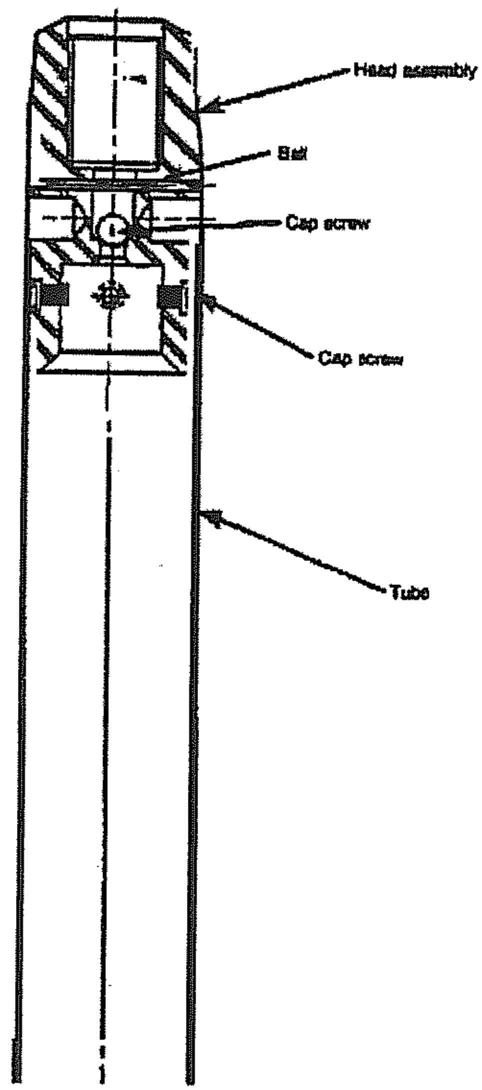


FIGURE 4

THIN-WALL TUBE SAMPLER



SOP APPROVAL FORM

THE PRESIDIO TRUST

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

GROUNDWATER SAMPLING

SOP NO. 002

REVISION NO. 00

Last Reviewed: December 2000

Quality Assurance Approved

12 JAN 01

Date

1.0 BACKGROUND

Groundwater sampling is conducted where there is a need to examine the chemical composition of groundwater contaminants. Groundwater can be sampled from an exploratory boring, pit or trench but the most reliable chemical data requires sampling from a properly constructed monitoring well. Groundwater sample collection procedures, when using low flow technology, are discussed in standard operating procedure (SOP) No. 003.

1.1 PURPOSE

This SOP establishes the requirements and procedures for sampling of groundwater from a properly constructed monitoring well (refer to SOP No. 004 for well installation procedures).

1.2 SCOPE

This SOP applies to groundwater sampling activities conducted in the field.

1.3 DEFINITIONS

Bailer: A cylindrical sampling device with valves on either end used to extract water from a well. Bailers are usually constructed of an inert material such as stainless steel or polytetrafluoroethylene (Teflon®). The bailer is lowered and raised by means of a disposable rope or a cable that may be cleaned and reused.

Electrical Water Level Indicator: An electrical device that has a light or sound alarm connected to an open circuit used to determine the depth to fluid. The circuit is closed when the probe intersects a conducting fluid. The wire used to raise and lower the probe is usually graduated in feet and inches.

Immiscible Phase: Liquid phases (such as oils) that cannot be uniformly mixed or blended with water. Heavy immiscible phases sink, and light immiscible phases float on water.

Interface Probe: An electrical probe that determines the distance from the surface to air/water, air/immiscible liquid, or immiscible liquid/water interfaces.

Purge Volume: The volume of water that needs to be removed from the well to ensure that a sample representative of groundwater is taken.

Riser Pipe: The length of well casing above the ground surface.

Total Well Depth: The distance from the ground surface to the bottom of the well.

Water Level: The level of water in a well. Measured as depth to water or as elevation of water, relative to a reference mark or datum (typically a permanent mark etched on the top of the inner casing.

1.4 REFERENCES

U.S. Department of Energy. 1985. *Procedures for the Collection and Preservation of Groundwater and Surface Water Samples and for the Installation of Monitoring Wells: Second Edition.* N. Korte and P. Kearl (Editors). Technical Measurements Center, Grand Junction Projects Office. GJ/TMC-08.

U.S. Environmental Protection Agency (EPA). 1982. *Procedures Manual for Groundwater Monitoring at Solid Waste Disposal Facilities.* EPA-530/SW-611. August.

EPA. 1984. "Sampling at Hazardous Materials Incidents." EPA Hazardous Response Support Division, Cincinnati. 1984.

U.S. Geological Survey. 1984. *National Handbook of Recommended Methods for Water-Data Acquisition.* Reston, Virginia.

1.5 REQUIREMENTS AND RESOURCES

There are various options available to obtain groundwater samples. The procedures are outlined in the following section. The equipment needed to accomplish these procedures includes the following:

- Organic vapor detector with a flame ionization detector (FID) or a photoionization detector (PID)
- Pipe wrench
- Electrical water level indicator or interface probe
- Steel tape with heavy weight
- Purging device (type needed depends on well depth, casing diameter, type of sample desired - see sampling devices below)
- Sampling device (type needed depends upon depth to water and type of sample desired)
  - Bailer
  - Bladder pump

- Submersible (non-oil-bearing) pump
- Existing dedicated equipment
- Peristaltic pump
- Tubing

- Sample containers
- Wastewater containers
- Field logbook
- Stopwatch

Additional equipment is required to complete measurement of field parameters (for example, pH, specific conductance, and temperature) of the groundwater at the well.

2.0 PROCEDURES

Prior to sampling, a project-specific field sampling plan should be developed. The plan should take into consideration the site characteristics and should include:

- The specific repeatable water level measurement techniques and reference points for determining the depth to water and the depth to the bottom of the well
- The specific method of purging and selection of purging equipment
- The specific analytic method for measurements of field parameters and the selection of field analytical equipment
- The specific method of sample collection and selection of sampling equipment
- The order of sample bottle filling
- The sample chemical analytical parameters

The following sections discuss procedures for approaching the well, establishing a sample preparation area, preliminary well measurements, purging the well, and sample collection.

2.1 APPROACHING THE WELL

In general, all wells should be assumed to pose a health and safety risk until field measurements indicate otherwise. Approach wells from the upwind side. Record well appearance and general condition of the protective casing, surface seal, and surrounding area in the logbook.

Once at the well, the lead person should systematically use the organic vapor detector to survey the immediate area around the well (from the breathing zone to the top of the casing to the ground). If elevated FID and PID meter readings are encountered, retreat to a safe area and instruct the sampling team to put on the appropriate level of personal protective equipment (PPE).

Upon opening the well casing, the lead person should systematically survey inside the well casing, above the well casing in the breathing zone and the immediate area around the well. If elevated FID or PID meter readings in the breathing zone are encountered (see health and safety plan for action levels), retreat and put on appropriate PPE. It is important to remember that action levels are based on readings in the breathing zone, not within the well casing. Representative organic vapor detector readings will be recorded in the logbook.

2.2 ESTABLISHING A SAMPLE PREPARATION AREA

The sample preparation area is generally located upwind or to either side of the well. If elevated readings are encountered using an organic vapor detector, this area should be taped off and the sample preparation area should be located upwind, where ambient readings are found.

2.3 PRELIMINARY WELL MEASUREMENTS

Several preliminary well measurements should be made prior to initiating sampling of the well. These include determining water level and total well depth measurements, determining the presence of immiscible phases, and calculating purge volumes. All preliminary measurements will be recorded in the logbook, as they are determined.

2.3.1 Water Level and Total Well Depth Measurements

Water level measurements are to be made using an electric water-level indicator. This device sounds an alarm or illuminates a light when the measuring probe touches the water surface, thus closing an electrical circuit. The electric cable supporting the probe is usually graduated in decimal feet and can be read at the

well site directly. Water levels should be read to a precision of 0.01 foot. The distance between the static water level and the marked or notched location at the top of the riser pipe is measured. The height of the riser pipe above ground surface, as obtained from well location survey data, is then subtracted from the total reading to give the depth to static water. To improve the accuracy of the readings, each measurement should be for a series of three readings, and the values averaged. This helps to eliminate any gross measurement errors or errors due to kinks or bends in the wires, which may change the length when the device is raised and lowered.

The total well depth can be measured by using a steel tape with a heavy weight attached to the end. The tape is lowered into the well until resistance is met, indicating that the weight has reached the bottom of the well. The total well depth is then read directly from the steel tape to the 0.01-foot fraction. The distance between the bottom of the well and the marked or notched location on the riser pipe is measured. The height of the riser pipe above the ground surface, as obtained from well survey data, is then subtracted from the total reading to give the depth to the bottom of the well. To improve the accuracy of the readings, the weighted steel tape should be used to make a series of three readings, and the readings averaged.

2.3.2 Determining if Immiscible Phases are Present

If immiscible phase liquids are observed during the measurement of water level depth and well depth, additional measurements shall be taken to determine the product thickness. Organic liquids are measured by lowering an interface probe slowly to the surface of the liquid in the well. When the audible alarm sounds, record the depth. If the alarm is continuous, a floating immiscible layer has been detected. To determine the thickness of this layer, continue lowering the probe until the alarm changes to an oscillating signal. The oscillating signal indicates that the probe has detected an aqueous layer. Record this depth as the depth to water and determine the thickness and the volume of the immiscible layer.

Continue lowering the probe into the well to determine if immiscible dense phases (sinkers) are present. If the alarm signal changes from oscillating to a continuous sound, a heavier immiscible layer has been detected; record this depth.

Continue lowering the probe to the bottom of the well and record the total depth. Separate total depth measurements with a steel tape are not necessary when using an interface probe. Calculate and record the sinker phase volume and total water volume in the well. Table 1 is provided to assist in these calculations. If immiscible phases are present, immediately refer to Section 2.5.1 or 2.5.2 of this SOP.

TABLE 1

LIQUID VOLUME IN A 1-FOOT SECTION OF A WELL BORING

Well Borehole Diameter (D_1) (inches)	Well Casing Diameter (D_2) (inches)	Volume of Liquid in 1-Foot Well Section (gallons)
7	2	0.71
8	2	0.90
10	4	1.68
12	4	2.22

2.3.3 Determination of Purging Volume

If the presence of organic liquids does not need to be determined, determine the depth to water and the total depth of the well as described in Section 2.3.1. Once these measurements have been made and recorded, use Table 1 to calculate the total volume of water in the well. In Table 1, the volume of water in a 1-foot section of a 2-inch-diameter well (8-inch borehole) is 0.90 gallon. This chart can easily be used for any water depth by multiplying the appropriate value in Table 1 by the depth (in feet) of water in the well. This volume is then multiplied by the purging factor to determine purging volume. The minimum purging factor is three borehole volumes but may be superseded by site-specific program requirements, individual well yield characteristics, or stabilization of field parameters measured during purging. Field parameters (for example, pH, specific conductance, and temperature) should be measured before purging and after each well volume. All field parameter data are recorded in the field logbook or field data form.

The volume of water to be purged is based on the following formulae:

$$V = [(AV \times n) + CV] \times L \times CF \times PF$$

$$AV = \frac{\pi}{4} \times (D_1^2 - D_2^2)/144$$

$$CV = \frac{\pi}{4} \times (D_2^2)/144$$

where:

V	=	volume of water in the well (gallons)
AV	=	annular volume (cubic-feet per foot)
CV	=	casing volume (cubic-feet per foot)
D_1	=	borehole diameter (inches)
D_2	=	well casing diameter (inches)
L	=	depth of water in the well (feet)
n	=	porosity of filter pack (assumed to be 0.30)
CF	=	conversion factor of 7.48 (gallons per cubic-foot)
PF	=	purging factor (generally a minimum of 3.00)

Note that temporary wells with no filter pack should use the casing volume times the purging factor to calculate the required purge volume.

2.4 PURGING THE WELL

Representative groundwater samples require that wells are purged prior to sampling. There are two acceptable purging methods, (1) three well volume purging and (2) low-flow purging (refer to SOP No. 003 for the low-flow methods). Well purging can be achieved using a variety of options including:

1. Bailers
2. Bladder pumps
3. Submersible (non-oil-bearing) pumps
4. Existing dedicated equipment, if any
5. Peristaltic pumps

As previously stated, the established minimum purging volume is three borehole volumes. The exception to this standard is in the case of low-yield wells. When purging low-yield wells, purge the well once to dryness. Samples should be collected as soon as the well recovers. When the time required for full recovery exceeds 3 hours, samples should be collected as soon as sufficient volume is available.

The well should be purged until the measured field parameters have been stabilized. If any field parameter has not stabilized, additional purging should be performed. To be considered stable, field parameters should change by no more than the tolerance levels listed on Table 2 between each well volume purged.

TABLE 2

FIELD MEASUREMENT TOLERANCE LEVELS

Field Parameter	Tolerance Level
pH	0.1 pH unit
Specific Conductance	10 percent
Temperature	1 °C

At no time should the purging rate be high enough to cause the groundwater to cascade back into the well, resulting in excessive aeration and potential stripping of volatile constituents.

The actual volume of purged water can be measured using several acceptable methods:

- When bailers are used, the actual volume of each bailer's contents can be measured using a calibrated bucket.
- If a pump is used for purging, the pump rate can be determined by using a bucket of known volume, stopwatch, and the duration of pumping time necessary to purge the known volume.

2.5 SAMPLE COLLECTION

The technique used to withdraw a groundwater sample from a well should be selected based on the parameters for which the sample will be analyzed. To ensure that the groundwater samples are representative, it is important to avoid physically altering or chemically contaminating the sample during collection, withdrawal, or containerization. If the samples are to be analyzed for volatile organic compounds, it is critical that air does not become entrained in the water column.

Acceptable sampling devices for all parameters are double check valve stainless steel or Teflon® bailers, bladder pumps, low-flow positive displacement pumps, or for shallow wells, peristaltic pumps. Additional measurements of field parameters should be performed at the time of sampling.

In some cases, it may become necessary to use dedicated equipment already in the well to collect samples. This is particularly true of high volume, deep wells (greater than 150 feet) where bladder pumps are ineffective and bailing is impractical. If existing equipment must be used, however, determine the make and model of the pump and obtain information on component construction materials from the manufacturer or facility representatives. If an existing pump is to be used for sampling, make sure the flow volume can be reduced so that a reliable sample for volatile organic compounds (VOC) analysis can be taken. Record the specific port, tap, or valve from which the sample is collected.

General sampling procedures include the following:

- Clean sampling equipment should not be placed directly on the ground. Use a plastic drop cloth or feed line from clean reels. Never place contaminated lines back on reels.
- Check the operation of the bailer check valve assemblies to confirm free operation.
- If the bailer cable is to be decontaminated and reused, it must be made of Teflon®-coated stainless steel.
- Lower sampling equipment slowly into the well to avoid degassing the water and damaging the equipment.
- Pump flow rates should be adjusted to eliminate intermittent or pulsed flow. The settings should be determined during the purging operations.
- A separate sample volume should be collected to measure necessary field parameters. Samples should be collected and containerized in the order of the parameters' volatilization sensitivity. Table 3 lists the preferred collection order for some common groundwater parameters.

TABLE 3

ORDER OF PREFERRED SAMPLE COLLECTION

1. VOC
2. Purgeable organic halogens (POX)
3. Total organic halogens (TOX)
4. Cyanide
5. Extractable organics
6. Purgeable organic carbon (POC)
7. Total metals
8. Dissolved metals
9. Total organic carbon (TOC)
10. Phenols
11. Sulfate and chloride
12. Nitrate and ammonia
13. Radionuclides

Intermediate containers should never be used to prepare VOC samples and should be avoided for all parameters in general. All VOC containers should be filled at a single sampling point or from a single bailer volume.

2.5.1 Collection of Light Immiscible Floaters

The approach used when collecting floaters is dependent on the depth to the floating layer and the thickness of that layer. If the thickness of the floater is 2 feet or greater, a bottom-filling valve bailer should be used. Slowly lower the bailer until contact is made with the floater surface, and lower the bailer to a depth less than that of the floater/water interface depth as determined by preliminary measurements with the interface probe.

When the thickness of the floating layer is less than 2 feet, and the depth to the surface of the floating layer is less than 15 feet, a peristaltic pump with tubing can be used to extract a sample.

When the thickness of the floating layer, however, is less than 2 feet and the depth to the surface of the floating layer is beyond the effective "lift" of a peristaltic pump (greater than 25 feet), a bailer can be modified to allow filling from the top only (an acceptable alternative is to use a top-loading Teflon® or stainless-steel bailer). Disassemble the bailer's bottom check valve and insert a piece of 2-inch diameter Teflon® sheet between the ball and ball seat. This will seal off the bottom valve. Remove the ball from the top check valve, thus allowing the sample to enter from the top. To overcome buoyancy when the bailer is lowered into the floater, place a length of one-inch stainless steel pipe on the retrieval line above the bailer (this pipe may have to be notched to allow sample entry if the pipe remains within the top of the bailer). Or, as an alternative, use a top-loading stainless-steel bailer. Lower the device, carefully measuring the depth to the surface of the floating layer, until the top of the bailer is level with the top of the floating layer. Lower the bailer an additional one-half thickness of the floating layer and collect the sample. This technique is the most effective method of collection if the floating layer is only a few inches thick. Note that immiscible layers must be collected before any purging activities.

2.5.2 Collection of Heavy Immiscible Sinkers

The best method for collection of sinkers is use of a double check valve bailer. The key to collection is controlled, slow lowering and raising of the bailer to and from the bottom of the well. Collection methods are equivalent to those described in Section 2.5.1 above.

2.5.3 Collection of Volatile Organics Samples

This section discussesin detail the collection of samples for VOC analysis using either a bailer or bladder pump. Other pumps (such as positive displacement or peristaltic) can be used. Critical factors to the collection of representative VOC samples include ensuring that no air becomes entrained in the water column, maintaining low pump flow rates (less than 100 milliliter [mL] per minute, if possible), and avoiding flow surges.

2.5.3.1 Collection with Bailers

VOC samples should be collected from the first bailer removed from the well after purging. The most effective approach requires two people. One person should retrieve the bailer from the well and pour its contents into the appropriate number of 40-mL VOC vials, which are held by the second person. Each vial is then capped and inverted. If the sample vial has a bubble, unscrew the cap and add more water, or discard and repeat. The sample is transferred from the bailer to the sample container in a manner to limit the amount of agitation and reduce the loss of volatile organics from the sample. Always fill VOC vials from a single bailer volume. If the bailer is refilled, samples cannot be considered duplicates or splits.

2.5.3.2 Collection with a Bladder Pump

To successfully perform VOC sampling with a bladder pump, the following steps must be completed:

1. Following manufacturer's directions, activate the pump. Full water flow from the discharge tubing will begin after 5 to 15 pumping cycles. These initial pumping cycles are required to purge air from the pump and discharge tubing. The discharge and recharge settings must be manually set and adjusted to pump at optimum flow rates. To activate the bladder, it is best to set the initial cycle at long discharge and recharge rates.

2. Reduce the water flow rate for VOC sample collection. To reduce the water flow rate, turn the throttle control valve (located on the left side of the pump control panel) counterclockwise.

3. Collect a VOC sample from discharge tubing. VOC vials must be placed beneath the discharge tubing while avoiding direct contact between the vials and the tubing. <u>Never</u> place tubing past the mouth of the VOC vial. The pump throttle control must be turned as necessary to maintain a trickle of water in order to obtain a meniscus in the vial.

4. Continue with non-VOC sampling. Increase pump flow rate by turning the throttle control knob clockwise.

ATTACHMENT A

MONITORING WELL SAMPLING LOG

MONITORING WELL SAMPLING LOG

Well No.: MWO No.:________ Day/Date:____________

Site/Project Name:____

Organic Vapor Concentrations Top of Casing:______ppm Breathing Zone______ppm

Depth to bottom: [ ] ft. below top of casing
Depth to water: [ ] ft. below top of casing

Initial D.O. Readings
Position in Screened Interval
Top: ______mg/L
Middle: ______mg/L
Bottom: ______mg/L

	Water Column		Purge Volume	
[ ] 2-inch well	[ ]	ft. x 0.163 gal/ft x 3 =	[ ]	gal.
[ ] 4-inch well	[ ]	ft. x 0.652 gal/ft x 3 =	[ ]	gal.
[ ] _-inch well	[ ]	ft. x _____ gal/ft x 3 =	[ ]	gal.

Method of Extraction: [ ] Disposable Bailer [ ] Other:____________

Groundwater Parameters

Time	Volume Purged (gal.)	Temp. (^{o}C)	Specific Conductivity (mS/cm)	Salinity (ppt)	Dissolved Oxygen (mg/L)	pH	Turbidity (NTU)	Other

Purged Dry? [ ] Field measurement equipment used: ____________________

Groundwater Samples Collected

Analytes of Concern		Fate and Transport Data			
Off-Site Lab		*Off-Site Lab*		*Field Test Kit Analyses*	
Metals	[ ] -Filtered	Anions	[ ]	Alkalinity	[ ]
PCBs	[ ]	M/E/E	[ ]	Fe^{2+}	[ ] F-y/n [ ]
SVOCs	[ ]	Sulfide	[ ]	Mn^{2+}	[ ] F-y/n [ ]
TPH-e	[ ]	TDS	[ ]		
TPH-p	[ ]	VOCs	[ ]		
VOCs	[ ]			F-y/n= note (yes/no) filtered samples. Filter where turbidity > 100 NTU.	

Sampler(s):____

Sample Number(s):____________________ Sample Date/Time:________________

Sample Collection Method: [ ] Disposable Bailer [ ] Other:

QA/QC Sample(s)? [ ] None [ ] Field Duplicate [ ] MS/MSD

Dup. Sample Number:____________________ Dup. Sample Date/Time:________________

Comments:

Sheet ___ of ___

SOP APPROVAL FORM

THE PRESIDIO TRUST

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

GROUNDWATER SAMPLE COLLECTION USING LOW-FLOW TECHNOLOGY

SOP NO. 003

REVISION NO. 00

Last Reviewed: December 2000

Quality Assurance Approved

12 JAN 01

Date

1.0 BACKGROUND

Groundwater sample collection is an integral part of site characterization at many contaminant release investigation sites. Often, a requirement of groundwater contaminant investigation is to evaluate contaminant concentrations in the aquifer. Since data quality objectives of most investigations require a laboratory setting for chemical analysis, samples must be collected from the aquifer and submitted to a laboratory for analysis. Therefore, sample collection and handling must be conducted in a manner that minimizes alteration of chemical characteristics of the groundwater.

In the past, most sample collection techniques followed federal and state guidance. Acceptable protocol included removal of water in the casing of a monitoring well (purging), followed by sample collection. The water in the casing was removed so groundwater from the formation could flow into the casing and be available for sample collection. Sample collection was commonly completed with a bailer, bladder pump, controlled flow impeller pump, or peristaltic pump. Samples were preserved during collection. Often, samples to be analyzed for metals contamination were filtered through a 0.45-micron filter prior to preservation and placement into the sample container.

Research conducted by several investigators has demonstrated that a significant component of contaminant transport occurs while the contaminant is sorbed onto colloid particles. Colloid mobility in an aquifer is a complex, aquifer-specific transport issue, and its description is beyond the scope of this standard operating procedure (SOP). However, concentrations of suspended colloids have been measured during steady-state conditions and during purging activities. Investigation results indicate standard purging procedures can cause a significant increase in colloid concentrations, which in turn may bias analytical results.

Low-flow sample collection provides a method of minimizing increased colloid mobilization by removing water from the well at the screened interval at a rate that preserves or minimally disrupts steady-state flow conditions in the aquifer. During low-flow sampling, groundwater is discharged from the aquifer at a rate that the aquifer will yield without creating a cone of depression around the sampled well. Research indicates that colloid mobilization will not increase above steady-state conditions during low-flow discharge. Therefore, the collected sample is more likely to represent steady-state groundwater chemistry.

1.1 PURPOSE

The purpose of this SOP is to describe the procedures to be used to collect a groundwater sample from a well using the low-flow technology. The following sections describe the equipment to be used and the methods to be followed to promote uniform sample collection techniques by field personnel that are experienced in sample collection and handling for environmental investigations.

1.2 SCOPE

This SOP applies to groundwater sampling using the low-flow technology. It is intended for use as an alternate SOP to the general "Groundwater Sampling" SOP (SOP No. 002), which provides guidance for the general aspects of groundwater sampling.

1.3 DEFINITIONS

Colloid: Suspended particles that range in diameter from 5 nanometers to 0.2 micrometer.

Dissolved Oxygen: The ratio of the concentration or mass of oxygen in water relative to the partial pressure of gaseous oxygen above the liquid which is a function of temperature, pressure, and concentration of other solutes.

Flow-through Cell: A device connected to the discharge line of a groundwater purge pump that allows regular or continuous measurement of selected parameters of the water and minimizes contact between the water and air.

pH: The negative base-10 logarithm of the hydrogen-ion activity in moles per liter.

Reduction and Oxidation Potential: A numerical index of the intensity of oxidizing or reducing conditions within a system, with the hydrogen-electrode potential serving as a reference point of zero volts.

Specific Conductance: The reciprocal of the resistance in ohms measured between opposite faces of a centimeter cube of aqueous solution at a specified temperature.

Turbidity: A measurement of the suspended particles in a liquid that have the ability to reflect or refract part of the visible portion of the light spectrum.

1.4 REFERENCES

Puls, R.W., and M.J. Barcelona. 1996. "Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures." U.S. Environmental Protection Agency. Office of Research and Development. EPA/540/S-95/504. April.

1.5 REQUIREMENTS AND RESOURCES

The following equipment is required to complete low-flow sample collection:

- Water level indicator
- Adjustable flow rate pump (bladder, piston, peristaltic, or impeller)
- Discharge flow controller
- Flow-through cell
- pH probe
- Dissolved oxygen (DO) probe
- Turbidity meter
- Oxidation and reduction (Redox or Eh) probe
- Specific conductance (SC) or salinity probe (optional)
- Temperature probe (optional)
- Meter to display data for the probes
- Calibration solutions for pH, SC, turbidity, and DO probes, as necessary
- Container of known volume for flow measurement or calibrated flow meter
- Data recording and management system

2.0 PROCEDURES

The following procedures and criteria were modified from U.S. Environmental Protection Agency guidance titled "Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures" (Puls and

Barcelona 1996). This reference may be consulted for a more detailed description of low-flow sampling theory.

Low-flow sampling is most commonly accomplished with low-discharge rate pumps, such as bladder, piston, controlled velocity impeller, or peristaltic pumps. Bailers and high capacity submersible pumps are not considered acceptable low-flow sample collection devices. The purged water is monitored (in a flow-through cell or other constituent monitoring device) for chemical and optical parameters that indicate steady-state flow conditions between the sample extraction point and the aquifer. Samples are collected when steady-state conditions are indicated.

Groundwater discharge equipment may be permanently installed in the monitoring well as a dedicated system, or it can be installed in each well as needed. Most investigators agree that dedicated systems will provide the best opportunity for collecting samples most representative of steady-state aquifer conditions, but the scope of a particular investigation and available investigation funds will dictate equipment selection.

2.1 EQUIPMENT CALIBRATION

Prior to sample collection, the monitoring equipment used to measure pH, Eh, DO, turbidity, and SC should be calibrated or checked according to manufacturer's directions. Typically, calibration activities are completed at the field office at the beginning of sampling activities each day. The pH meter calibration should bracket the pH range of the wells to be sampled (acidic to neutral pH range [4.00 to 7.00] or neutral to basic pH range [7.00 to 10.00]). The DO meter should be calibrated to one point (air-saturated water) or two points (air-saturated water and water devoid of all oxygen). The SC meter cannot be calibrated in the field. It is checked against a known standard (typical standards are 1, 10, and 50 millimhos per centimeter at 25 °C). The offset of the measured value of the calibration standard can be used as a correction value. Similarly, the Eh probe cannot be calibrated in the field, but is checked against a known standard, such as Zobell solution. The instrument should display a millivolt (mV) value that falls within the range set by the manufacturer. Because Eh is temperature dependent, the measured value should be corrected for site-specific variance from standard temperature (25 °C). The Eh probe should be replaced if the reading is not within the manufacturer's specified range. All calibration data should be recorded on the Low-flow Groundwater Sampling Data Sheet attached to this SOP (or equivalent).

2.2 WELL PURGING

The well to be sampled should be opened and groundwater in the well allowed to equilibrate to atmospheric pressure. Equilibration should be determined by measuring depth to water below the marked reference on the wellhead (typically the top of the well casing) over two or more 5-minute intervals. Equilibrium conditions exist when the measured depth to water varies by less than 0.01 foot over two consecutive readings. Total depth of well measurement should be made following sample collection, unless the datum is required to place nondedicated sample collection equipment. Depth to water and total well depth measurements should be made in accordance with procedures outlined in SOP No. 002 (Static Water Level, Total Well Depth, and Immiscible Layer Measurement).

If the well does not have a dedicated sample collection device, a new or previously decontaminated portable sample collection device should be placed within the well. The intake of the device should be positioned based on the fate and transport and lithological conditions at the site. The device should be installed slowly to minimize disturbance of the water in the casing and mixing of stagnant water above the screened interval with water in the screened interval. Following installation, the flow controller should be connected to the sample collection device and the flow-through cell connected to the outlet of the sample collection device. The calibrated groundwater chemistry monitoring probes should be installed in the flow-through cell. If a flow meter is used, it should be installed ahead of the flow-through cell.

If the well has a dedicated sample collection device, the controller for the sample collection device should be connected to the sample collection device. The flow meter and flow-through cell should be connected in line to the discharge tube, and the probes installed in the flow-through cell.

The controller should be activated and groundwater pumped (purged) from the well. The purge rate should be monitored, and should not exceed the capacity of the well. The well capacity is defined as the maximum discharge rate that can be obtained with less than 0.1-meter (0.3 foot) drawdown. Typically, the discharge rate will be less than 0.5 liters per minute (L/min) (0.13 gallon per minute [gpm]). The maximum purge rate should not exceed 1.0 L/min (0.25 gpm), and should be adjusted to achieve minimal drawdown.

Water levels, effluent chemistry, and effluent flow rate should be continuously monitored while purging the well. Purging should continue until the measured chemical and optical parameters are stable. Stable

parameters are defined as monitored chemistry values that do not fluctuate by more than the following ranges over three successive readings at 3-minute intervals: ±0.1 pH unit; ±3 percent for SC; ±10 mV for Eh; and ±10 percent for turbidity and DO. At a minimum, two times the internal volume of the pump (typically, 300 milliliters) and the pump tubing (9.7 milliliters per foot of standing water) must be purged. Purging will continue until the stabilization criteria have been met or three well borehole volumes have been purged (see SOP No. 002 for appropriate volume). If three borehole volumes of water have been purged and the stabilization criteria have not been met, a comment should be made on the data sheet that sample collection began before the groundwater had stabilized. The final pH, SC, Eh, turbidity, and DO values will be recorded. All data should be recorded on the Low-flow Groundwater Sampling Data Sheet attached to this SOP (or equivalent).

2.3 SAMPLE COLLECTION

Following purging, the flow through cell should be disconnected, and groundwater samples collected directly from the discharge line. Discharge rates should be adjusted so that groundwater is dispensed into the sample container with minimal aeration of the sample. Samples collected for volatile organic compound analysis should be dispensed into the sample container at a flow rate equal to or less than 0.1 L/min. Samples should be preserved and handled as described in the project-specific field sampling plan.

ATTACHMENT A

MONITORING WELL SAMPLING LOG (LOW-FLOW)

Monitoring Well Sampling Log (Low Flow)

MWO#: ____________ **Project/Site Name:** ______________________________ **Date:** ____________ **Well ID:** ____________

Well Data:

Casing Diameter: ____________
Borehole Diameter: ____________
Depth of Casing (ft bTOC): ____________
Screen Interval (ft bTOC): ____________
Pump Intake (ft bTOC): ____________
Well Condition (Comments): ____________
____
Weather (temp/pressure/wind): ____________
____

Initial Measurements & Calculations:

Initial PID Reading at TOC (ppm): ____________
Depth to Product (ft bTOC; NA if none): ____________
Product Thickness (ft bTOC): ____________
Static Depth to Water (ft bTOC): ____________
Standing Water Column (ft): ____________
a) One Pump Volume (mL): 300 mL
b) One Tube Volume (mL): ft x (9.7 ml/ft)= ______ mL
c) One Purge Volume (=a+b): ______ mL
Minimum Volume to be Purged (=2xc): ______ mL

Equipment Documentation:

Water Level Meter: ____________
Product Probe/Sampler (NA if none): ____________
Multi-Parameter Meter: ____________
PID: ____________
Purge/Sample Pumps: ____________
Control Box Settings:
Pressure (psi): ____________
Fill Cycle (sec): ____________
Pump Cycle (sec): ____________

All measurements taken from the surveyor mark at top of casing, or north side if no mark exists.

Time	Amount Purged (mL)	Field Parameters Measured: Temp. (°C)	Salinity (%)	pH	S.C. (mS/cm)	Turbidity (NTU)	D.O. (mg/L)	ORP (mV)	PID Breathing Zone / TOC	Depth to Water (ft bTOC)	Flow Rate (mL/min)	Comments (field observations, odor, color, problems, well performance, etc.)	Field Tech.
												(flow reduced to ____ ml/min prior to VOC collection)	
Sample													

Purge Information:

Purge Method (circle one): Marshalk System / Aquarious / Bladder Pump
Time Purging Began: ____________
Total Milliliters Purged: ____________
Total Pump/Tubing Volumes Purged: ____________
Time Purging Completed: ____________

Sampling Information:

Sampling QA/QC Requirements (circle one): NA Dup/Split MS/MSD
Sampling Method: ____________
Time Sampling Began: ____________
Filter Type (size/brand): NA / QEC (0.45 micron) / Other:
Amount Flushed Through Filter (well water in mL): ____________
Time Sampling Completed: ____________

SOP APPROVAL FORM

THE PRESIDIO TRUST

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

WELL INSTALLATION

SOP NO. 004

REVISION NO. 00

Last Reviewed: December 2000

Quality Assurance Approved

12 JAN 01

Date

1.0 BACKGROUND

Well type, well construction, and well installation methods will vary with drilling method, well utility, subsurface characteristics, or other site-specific criteria. Specifications for well installation will be identified within a project-specific field sampling plan (FSP). A Monitoring Well Installation Record (Attachment A) will be completed for each well installed.

Well installation methods will depend somewhat on the boring method. In turn, the boring method will depend on site-specific geology and hydrogeology. Boring methods include:

- Hollow-stem auger
- Cable tool
- Rotary (mud, reverse, or air)
- Rock coring
- Direct push methods

The hollow-stem auger method is preferred in areas where subsurface materials are unconsolidated or loosely consolidated and where the depth of the boring will be generally less than 100 feet. This maximum depth is dependent on the diameter of the augers, the formation characteristics, and the strength and durability of the drilling equipment. This method is preferred because it is quick and inexpensive, addition of water into the subsurface is limited, and continuous samples can easily be collected.

Cable tool drilling is a preferred method when the subsurface contains boulders, coarse gravels, or flowing sands, or when the operational depth of the hollow-stem auger is exceeded. This method, however, is slow.

Rotary methods are generally used when other methods cannot be used. The use of drilling fluids or large amounts of water to maintain an open borehole, and the difficulty in obtaining representative samples limit this method's utility. However, this method can be used to quickly and effectively drill deep wells through consolidated or unconsolidated materials. Modifications of this method such as dual-tube drilling, drill-through casing hammers, or eccentric type drill systems can reduce the amount of fluids introduced into the well borehole.

Rock coring is an effective method when drilling in competent consolidated rock. Intact, continuous cores can be obtained, and limited amounts of fluid are required if the formations are not fractured.

Direct-push methods can be used to install shallow, water table well points in unconsolidated soils. Direct-push methods have the advantage of being rapid and relatively inexpensive, but are generally not suitable where flowing sands or consolidated material exist. In addition, this approach frequently produces a significantly more turbid sample than would be obtained from a comparable conventional monitoring well.

1.1 PURPOSE

This standard operating procedure (SOP) discusses general types of wells and minimum standards for well installation.

1.2 SCOPE

This SOP describes procedures for well installation using various methods. It includes procedures applicable to hollow-stem auger, cable tool, rotary (mud, reverse, or air), and rock coring. It also discusses more specialized wells and methods, such as direct-push installation of well points.

1.3 DEFINITIONS

None.

1.4 REFERENCES

Aller, L. 1989. *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells.* National Well Water Association (NWWA). Pages 145 through 246.

California Environmental Protection Agency. 1995. "Monitoring Well Design and Construction for Hydrogeologic Characterization." *Guidance for Ground Water Investigations.* July.

Driscoll, F.G. 1986. *Groundwater and Wells.* Second Edition. Johnson Division, UOP, Inc. St. Paul, Minnesota. Pages 438 through 442.

1.5 REQUIREMENTS AND RESOURCES

There are various options available for well installation depending on the boring method. The procedures and equipment required are outlined in the following sections.

2.0 PROCEDURES

This section details the minimum general monitoring well installation criteria and procedures. Site-specific geologic regimes may result in departures from this procedure. Specific procedures should be detailed in a project-specific FSP. Figure 1 shows a typical completed monitoring well.

All wells will be equipped with factory slotted screen. Casings and screens should be threaded and flush coupled and watertight joints should be used. Casings and screens will be selected in accordance with criteria set forth in Section 2.1. Annular seals are described in Sections 2.2 and 2.3. General monitoring well installation should follow these steps:

1. Before the installation of any casing or screen into the borehole, the casing and screen material should be carefully visually inspected for any cracks, breaks, or other defects. It should then be decontaminated (SOP No. 014 explains decontamination rationale and procedures).

2. Well casing and screens should be anchored within the borehole using centralizers.

3. The filter pack and other annular sealing materials should be installed through the auger stem or borehole casing. A tremie pipe should be used to install this material and a weighted tape should be used to tamp material. The tremie pipe is slowly raised as material is added to the annular space. When wells are constructed in temporary casing such as hollow stem augers the augers should be lifted when 1 to 2 feet of construction material has accumulated in the annulus. The casing should be lifted enough so that the accumulated material settles to within 2 to 4 inches of the bottom of the temporary casing.

4. Screens will be placed within a filter pack. This filter pack will be constructed in the manner detailed in Section 2.2 and will extend a minimum of 2 feet above and no more than 2 feet below the screened interval.

5. A fine sand collar should be installed to 2 feet above the top of the filter pack.

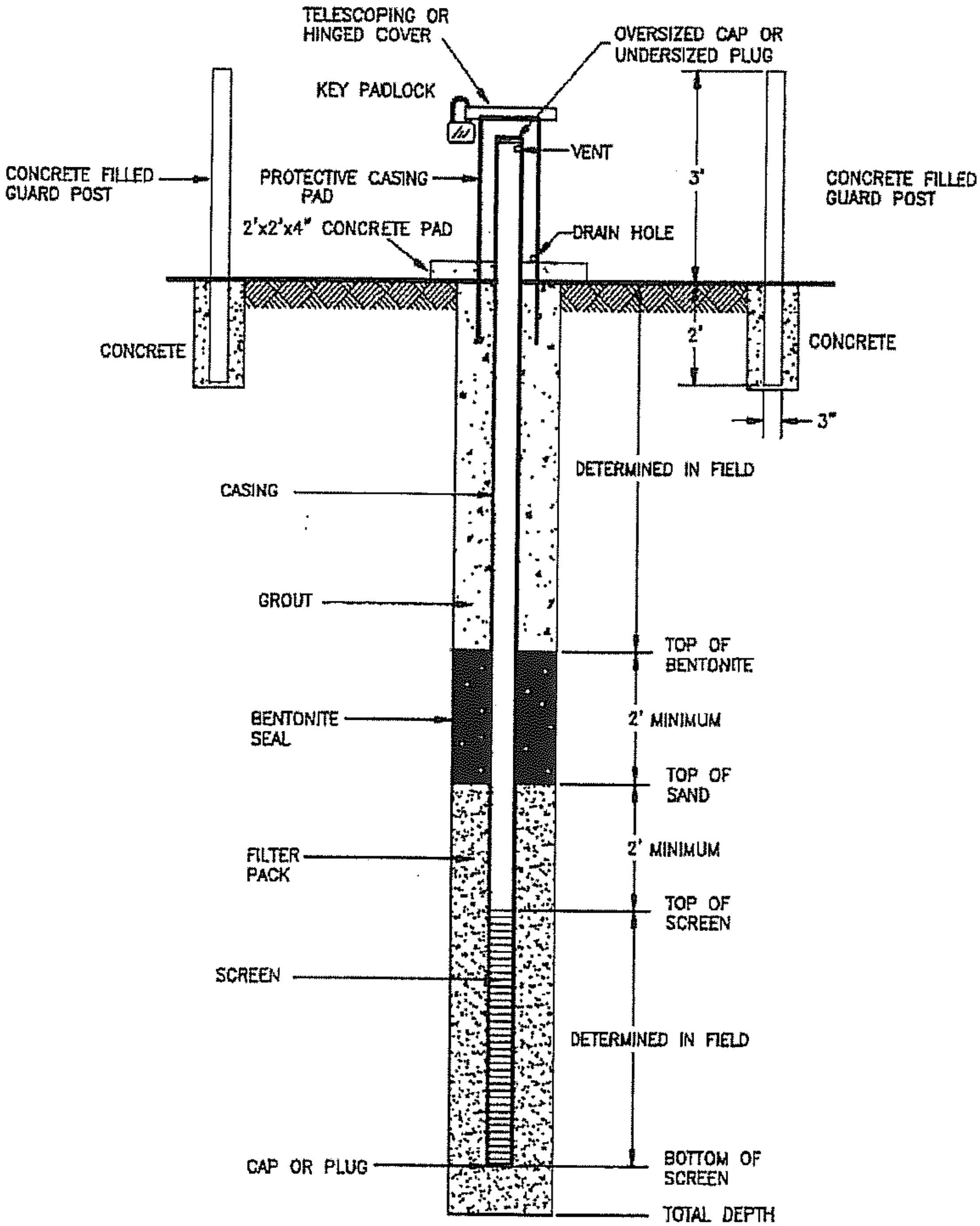
6. A minimum 2-foot thick bentonite slurry seal will be placed above the filter pack.

7. Bentonite cement slurry should be pumped through a tremie pipe into the annular space up to a point approximately 2-feet below the ground surface.

8. A protective outer casing and locking cap should then be placed in the borehole and a cement surface seal should be installed. The cement surface seal will form a pad around the monitoring well.

FIGURE 1

TYPICAL WELL CONSTRUCTION DIAGRAM



2.1 CASINGS AND SCREENS

The selection of well casing and screen materials must take into account environmental factors such as (1) geologic environment, (2) natural geochemical environment, (3) anticipated well depth, and (4) types and concentrations of known or suspected contaminants. Other nonenvironmental factors that will have an impact on the material selection include (1) anticipated life of the monitoring well, (2) drilling and installation methods, (3) cost, and (4) availability.

Inner casings and well screens should be constructed of inert, durable materials. Polyvinyl chloride (PVC) casings and screens will generally be preferred. However, PVC should not be used if the groundwater or soil contaminants react with PVC or if the well life is expected to be relatively long. Stainless steel, polytetrafluoride (Teflon®), and epoxy-fiberglass are sound well construction materials that may be employees in certain sampling environments. Epoxy-fiberglass well construction materials are relatively new to the environmental monitoring field; however, preliminary data suggests they are comparable to stainless steel, but about half the cost. Due to the recent introduction of this material into the groundwater monitoring field, local regulatory authorities should be consulted prior to the use of this material. Several states, U.S. Environmental Protection Agency regions, and U.S. Army Corps of Engineers Districts are using this material as an alternative to stainless steel.

Casing and screen joints should be threaded, and Teflon® tape should be used to assure a tight seal with Teflon® or stainless-steel components. Epoxy-fiberglass and PVC joints typically are fitted with rubber O-rings to provide a tight seal. Teflon® tape may also be applied to these joints to assure a prolonged tight seal. Under no circumstances should joints be glued or solvent sealed.

Screens will be factory-slotted. The screen slot size will be dependent on required flow rates for the well and the texture of the formation. When sieve analysis information is available for well packing material, slot sizes should be capable of retaining 90 percent of the filter pack material (see Section 2.2). When no such information is available, a default screen size of 0.01 inch (No. 10 slot) will be used.

Screen length and well diameter will depend on site-specific considerations. These include intended well use, contaminants of concern, and hydrogeology. Some considerations are as follows:

- Water table wells should have screens of sufficient length and thickness to monitor the water table and provide sufficient sample volume during high and low water table conditions.

- Wells with low recharge should have screens of sufficient length and width so that adequate sample volume can be collected.

- Wells should be screened over short enough distances to allow for monitoring of discrete migration pathways.

- Where light nonaqueous-phase liquids (LNAPL), or contamination in the upper portion of a hydraulic unit, are being monitored, the screen should be set so that the upper portion of the water-bearing zone is below the top of the screen.

- Where dense nonaqueous-phase liquids (DNAPL) are being monitored, the screen should be set within the lower portion of the water-bearing zone, just above a relatively impermeable lithologic unit.

- The screened interval should not extend across an aquiclude or aquitard.

- If contamination is known to be present and concentrated within a portion of a saturated zone, the screen should be constructed in a manner that minimizes the potential for cross-contamination within the aquifer.

- If downhole geophysical surveys are to be conducted, the casing and screen material must be of sufficient diameter and constructed of the appropriate material to allow effective use of the geophysical survey tools.

- If aquifer tests are to be conducted in a monitoring well, the slot size must allow sufficient flux to produce the required drawdown and recovery. The diameter of the well must be sufficient to house the pump and monitoring equipment and to allow sufficient water flux (in combination with the screen slot size) to produce the required drawdown or recovery.

In many instances, it may be necessary to isolate stratigraphically higher portions of the subsurface, during drilling, from the zone being monitored. In these cases, special types of drilling may be necessary. An example of this is the use of temporary or permanent borehole casing that is telescoped to smaller diameters with depth. With this approach, a large diameter casing is installed through the zone to be isolated and drilling is continued to depth through this casing. If necessary, additional smaller diameter casing can be installed to stabilize the formation or isolate progressively deeper stratigraphic units. Another alternative involves the drilling of a large diameter borehole to the base of the zone to be isolated. This borehole is then sealed with a cement-bentonite grout. When the grout has cured, the well installation borehole is drilled through the grout down to its final completion depth. Just as with the casing approach described above, progressively deeper units can be isolated by the grouting of the portion of the borehole, which penetrates, then advancing the borehole through the hardened grout.

Before installing the casing and screen, they should be fitted with centralizers to assure a uniform thickness of the annular seals. The annular seal is composed of the filter pack, sand collar, bentonite seal, and cement-bentonite grout. The annular seal should have a uniform thickness around the casing and screen of between 2 to 4 inches. Thinner seals increase the possibility that the well screen may be exposed to the formation, and thicker seals may interfere with aquifer hydraulics around the screen. The selection of the centralizer material should be based on the same criteria used to select the casing and screen material. The centralizers should be spaced at closer intervals for smaller diameter casing and screen. Two-inch casing and screen should have centralizers installed approximately every 20 feet.

2.2 FILTER PACK

The filter pack will be composed of chemically inert, uncontaminated material. The preferred filter pack material is pure silica sand.

Methods for choosing filter pack grain size should be clearly outlined in the project-specific field sampling plan. Filter pack material must be tailored to the formation material. One method for choosing the filter pack grain size is based on the method proposed by NWWA (Aller 1989). Using this method, at least one standard sieve analysis of formation material is obtained. The grain size that retains 70 percent of the material is noted. This grain size is multiplied by a factor of 4 or 6. The factor of 4 is used for coarse-grained, poorly sorted formations, and the factor of 6 is used for fine-grained, well-sorted formations. The resultant grain size is used as the 70 percent retained point for the grain size of the filter pack. A second more conservative approach is described by Driscoll (1986). In this approach, the filter pack size is based on multiplying the 50 percent retained formation grain size by 2. If formation particle-size distribution information is not available, an Ottawa grade sand, American Society for Testing and Materials (ASTM) C-778 sand, or equivalent can be considered for use. The use of a default-size filter pack becomes more tenuous in increasingly finer-grained formations. The uniformity coefficient of the filter pack should not exceed 2.5. The filter pack should have a finished uniform thickness of 2 to 4 inches.

The filter pack should extend 2 feet above the top of the well screen. A sand collar should be installed on top of the filter pack. The sand collar should be constructed from fine silica sand (0.0021- to 0.0041-inch diameter) and extend 2 feet above the filter pack. This sand collar is intended to prevent intrusion of bentonite and grout into the filter pack.

2.3 GROUT AND CEMENT

Bentonite slurry should be placed in the annular pack for a minimum of 2 feet above the fine sand collar. This slurry should be mixed at a ratio of approximately 22 pounds of dry bentonite to 7 gallons of water. This should result in 10- to 11-pound per gallon slurry. The bentonite slurry will act as a formation seal for the monitoring well borehole. Cement and bentonite grout slurry will be placed in the annular space above the bentonite slurry, generally to a point about 2 feet below ground surface. Sufficient time should be allowed for the bentonite slurry to gel to a strength able to support the cement and bentonite grout. When mixing the bentonite slurry with a low shear device such as the grout pump or a drill rig, 30 to 60 minutes of mixing should be conducted prior to placing the slurry into the well annulus. After 30 to 60 minutes of low shear mixing, the slurry should be thick enough to support the cement-bentonite grout. The cement and bentonite grout will consist of mixture of 8 gallons of water, 5 pounds of bentonite powder (approximately 5 percent of the mix), and a 94-pound sack of Portland cement. An alternative cement-bentonite grout would be a premixed commercially equivalent material. A cement surface seal will be placed at the surface. Specific construction criteria may vary. These should be detailed in the project-specific FSP.

Bentonite slurry used as a formation seal above the filter pack and sand collar can be replaced with a seal composed of bentonite pellets or chips. These materials should be added to the annulus slowly to prevent bridging. Lifts of 3 to 4 inches should be separated by sufficient time to allow settlement. Past experience has shown that natural bentonite chips have slower hydration characteristics and are not as prone to bridging as formed bentonite pellets.

Bentonite seals are not always appropriate. If they are installed in the vadose zone, they may never fully hydrate, or they can dry, creating desiccation cracks. Both situations cause seal failure. Groundwater with high chloride concentrations or total dissolved solids greater than 500 parts per million (ppm) may inhibit the full hydration of the bentonite. This could limit the effectiveness of the annular seal. The case of bentonite in areas were the seal may be exposed to high concentrations of organic solvents, hydrocarbons, organic acids, basic and natural polar-organic compounds, and neutral nonpolar organic compounds may result in a several order-of-magnitude increase in the permeability of the seal. Neat cement is an alternative to bentonite seals given any of the above environmental conditions. Neat cement is a mixture of Portland cement (ASTM C-150) and water in the ratio of 5 to 6 gallons of water to 94 pounds of cement. Type I Portland cement is the most commonly used material for this application.

2.4 OTHER COMPONENTS

The procedures below should be followed under specific circumstances. Several other well components, which may be necessary depending of project specifications, are listed below:

- **Locking Well Caps and Outer Protective Casings.** These will be placed on all completed wells. These can be either aboveground or flush mount.
- **Bumper Posts or Well Head Protection.** Protective bumper posts or other types of protective barriers should be placed around each well with an aboveground completion.
- **Telescoping or Conductor Casing.** Telescoping or conductor casing is used when wells are drilled to fairly deep depths when drilling proceeds through several separate saturated intervals, or when drilling through grossly contaminated intervals.

3.0 OTHER TYPES OF WELLS

This section discusses other types of wells that may be installed in special cases. These include well points, wells installed through multiple saturated zones, well nests, and bedrock wells.

3.1 WELL POINTS

Under certain conditions, it may be necessary to install well points. These wells are driven directly into the subsurface by sledgehammer, power impact driver, or direct push methods such as Geoprobe® or cone penetrometer testing methods. Applications include use as vadose zone monitoring or shallow piezometer wells. However, the geologic subsurface must be compatible with this method. The utility of this method is limited because the annular space is generally not sealed to the surface. These types of wells are not currently a widely accepted alternative to permanent monitoring well installations and should only be used under special circumstances.

3.2 WELLS INSTALLED THROUGH MULTIPLE SATURATED ZONES

When wells are installed through multiple saturated zones, special well construction methods have to be used to ensure well integrity and to limit the potential for cross-contamination. Generally, these types of wells are necessary if hydraulic units are separated by relatively impermeable layers. Two procedures that may be used are described below.

The borehole is advanced to the base of the first saturated zone. Casing is then anchored in the impermeable layer below and grouted to the surface. After the grouting has cured, a smaller diameter borehole is drilled through the grout. This procedure is repeated until the zone of interest is reached. After this zone is reached, a conventional well screen and riser casing is set.

Another acceptable procedure involves driving a casing through several saturated layers, while drilling ahead of the casing. This method, however, is not acceptable when a competent aquitard or aquiclude may be structurally damaged by the driven casing, because this method may result in cross-contamination of two saturated layers.

3.3 WELL NESTS

Well nests are installed when several distinct intervals in an aquifer are to be sampled at each groundwater sampling location. These wells can be completed similarly to those described in Section 2.0. These wells can be installed in a single borehole or in close proximity to each other. When installing multiple wells in a single borehole, extreme care should be exercised when placing bentonite slurry seals above the filter packs. These seals must prevent flow between the wells in the single borehole.

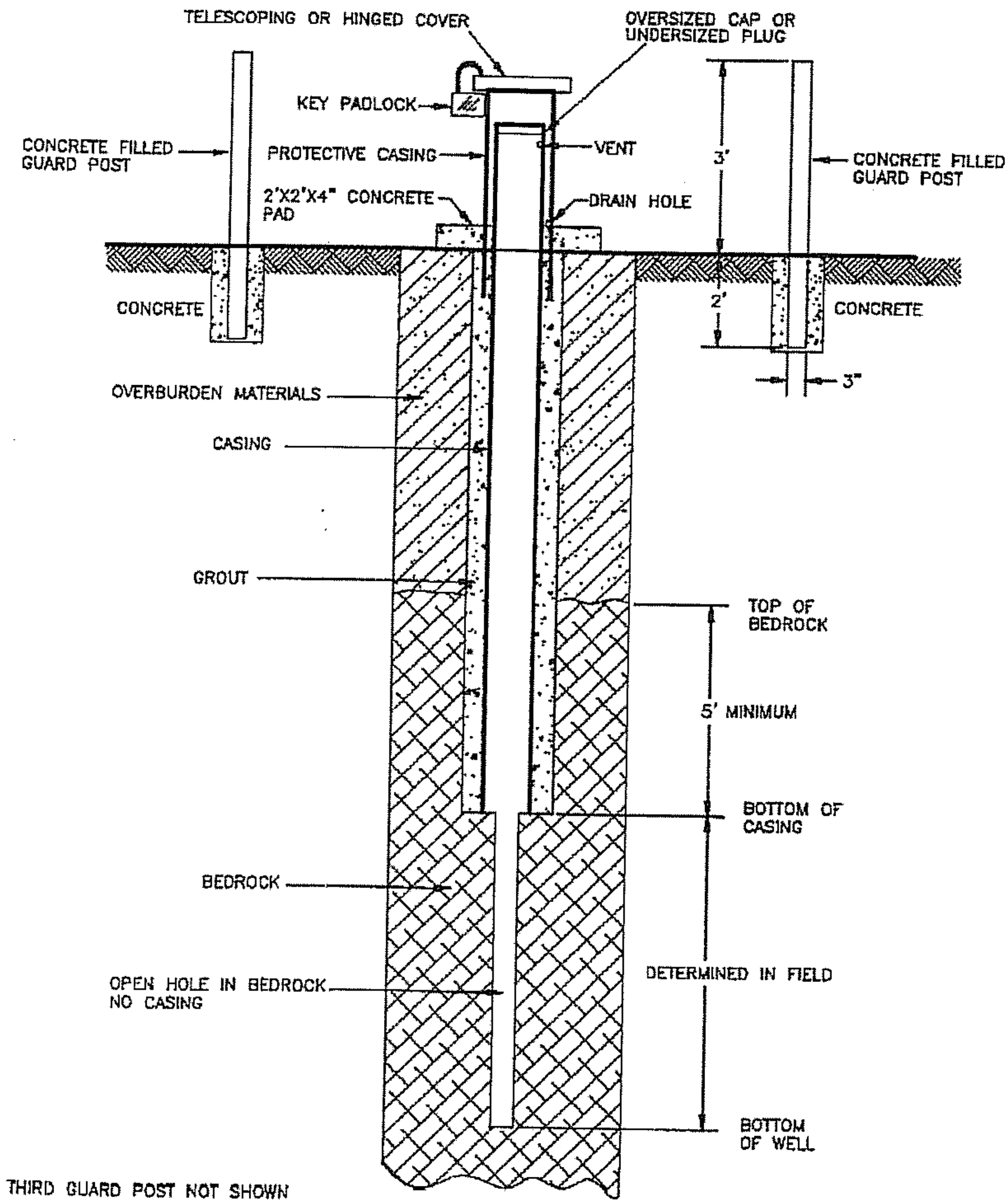
3.4 BEDROCK WELLS

Wells completed in bedrock will be drilled using the air or mud rotary method. Crystalline rock wells are usually drilled most efficiently with the air rotary method while consolidated sedimentary formations are drilled using either the air rotary or mud rotary method. The compressed air supply will be filtered prior to introduction into the borehole to remove oil or other contaminants. Bedrock wells may be completed as an open-hole, providing that borehole cave-in is not a possibility.

Bedrock wells will be advanced with air or mud rotary methods until a minimum of 5 feet of competent rock has been drilled. Minimum borehole diameter will be 8 inches. The drill string will then be pulled from the borehole and 6-inch I.D. Schedule 80 or 40 PVC casing inserted. Portland cement/bentonite grout will be pumped into the hole and up the annular space outside the casing. After the grout has set (minimum of 24 hours), the cement will be drilled out and the borehole advanced to the desired depth. Figure 2 shows typical construction details for an open-hole bedrock well. The preferred method of well completion for the bedrock wells will be open-hole. However, if the open borehole is subject to cave-in, the well(s) will be completed as screened and cased sand-packed wells.

FIGURE 2

TYPICAL BEDROCK WELL CONSTRUCTION



ATTACHMENT A

MONITORING WELL INSTALLATION RECORD

MONITORING WELL INSTALLATION RECORD

MONITORING WELL

MONITORING WELL NO.:
PROJECT:
SITE:
BOREHOLE NO.:
WELL PERMIT NO.:
TOC TO BOTTOM OF WELL:

DRILLING INFORMATION

DRILLING BEGAN:
DATE: TIME:
WELL INSTALLATION BEGAN:
DATE: TIME:
WELL INSTALLATION FINISHED:
DATE: TIME:
DRILLING CO.:
DRILLER:
LICENSE:
DRILL RIG:
DRILLING METHOD:
- ☐ HOLLOW STEM AUGER
- ☐ AIR ROTARY
- ☐ OTHER:

DIAMETER OF AUGERS:
ID: OD:

WELL CASING

☐ SCHEDULE 40 PVC
☐ OTHER:
PRODUCT:
MFG. BY:
CASING DIAMETER:
ID: OD:
LENGTH OF CASING:

WELL SCREEN

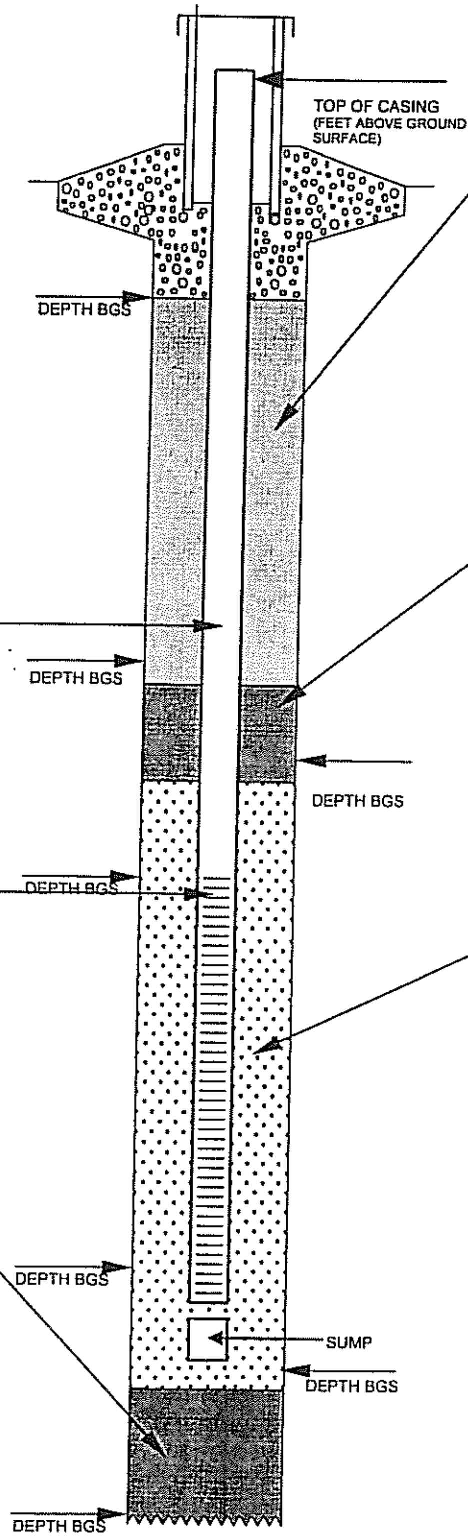
☐ SCHEDULE 40 PVC
☐ OTHER:
PRODUCT:
MFG. BY:
CASING DIAMETER:
ID: OD:
SLOT SIZE:
LENGTH OF SCREEN:

BOREHOLE BACKFILL

AMOUNT CALCULATED:
AMOUNT USED:
☐ BENTONITE CHIPS, SIZE:
☐ BENTONITE PELLETS, SIZE:
☐ SLURRY:
☐ FORMATION COLLAPSE:
☐ OTHER:
PRODUCT:
MFG. BY:
METHOD INSTALLED:
☐ POURED ☐ TREMIE
☐ OTHER:

SURFACE COMPLETION

☐ FLUSH MOUNT
☐ ABOVE GROUND WITH BUMPER POST
☐ CONCRETE ☐ ASPHALT



SURVEY INFORMATION

TOC ELEVATION:
GROUND SURFACE ELEVATION:
NORTHING:
EASTING:
DATE SURVEYED:
SURVEY CO.:

ANNULAR SEAL

VOLUME CALCULATED:
AMOUNT USED:
☐ GROUT FORMULA (PERCENTAGES)
PORTLAND CEMENT:
BENTONITE:
WATER:
☐ PREPARED MIX
PRODUCT:
MFG. BY:
METHOD INSTALLED:
☐ POURED ☐ TREMIE
☐ OTHER:

BENTONITE SEAL

VOLUME CALCULATED:
AMOUNT USED:
☐ PELLETS, SIZE:
☐ CHIPS, SIZE:
☐ OTHER:
PRODUCT:
MFG. BY:
METHOD INSTALLED:
☐ POURED ☐ TREMIE
☐ OTHER:
AMOUNT OF WATER USED:

FILTER PACK

☐ PREPACKED FILTER
VOLUME CALCULATED:
AMOUNT USED:
☐ SAND, SIZE:
PRODUCT:
MFG. BY:
METHOD INSTALLED:
☐ POURED ☐ TREMIE
☐ OTHER:
WATER LEVEL:
(BTOC AFTER WELL INSTALLATION)

CENTRALIZERS USED?

☐ YES ☐ NO;
CENTRALIZER DEPTHS:

LEGEND

BGS = BELOW GROUND SURFACE
BTOC = BELOW TOP OF CASING
N/A = NOT APPLICABLE
NR = NOT RECORDED
TOC = TOP OF CASING

SOP APPROVAL FORM

THE PRESIDIO TRUST

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

MONITORING WELL DEVELOPMENT

SOP NO. 005

REVISION NO. 00

Last Reviewed: December 2000

Quality Assurance Approved

12 JAN 01

Date

1.0 BACKGROUND

Well development should be conducted as an integral step of monitoring well installation to remove the finer-grained material, typically clay and silt, from the geologic formation near the well screen and filter pack. Monitoring well installation is discussed in standard operating procedure (SOP) No. 004. Well development improves the hydraulic connection between water in the well and water in the formation. The fine-grained particles may interfere with water quality analyses and alter the hydraulic characteristic of the filter pack and hydrologic unit adjacent to the well screen.

All drilling methods impair the ability of an aquifer to transmit water to a drilled hole. Typically, this impairment is a result of disturbance of soil grains (smearing) or the invasion of drilling fluids or solids into the aquifer during the drilling process. Nonetheless, the impact to the hydrologic unit surrounding the borehole must be remediated if the well hydraulics and sampling of the monitoring well are to be representative of the aquifer.

1.1 PURPOSE

This SOP establishes the requirements and procedures for monitoring well development.

Well development improves the hydraulic characteristics of the filter pack and borehole wall by performing the following functions:

- Reduce the compaction and the intermixing of grain sizes produced during drilling by removing fine material from the pore spaces.
- Remove the filter cake or drilling fluid film that coats the borehole, and remove much or all of the drilling fluid and natural formation solids that have invaded the formation.
- Create a graded zone of sediment around the screen, thereby stabilizing the formation so that the well can yield sediment-free water.

1.2 SCOPE

This SOP applies to the specifications and methodologies of monitoring well development.

1.3 DEFINITIONS

Aquifer: A geologic formation, group of formations, or part of a formation that is saturated, and is capable of storing and transmitting water.

Bailer: A cylindrical sampling device with valves on either end used to extract water from a well. Bailers are usually constructed of an inert material such as stainless steel or polytetrafluoroethylene (Teflon®). The bailer is lowered and raised by means of a cable that may be cleaned and reused or by disposable rope.

Conductance (Specific): A measure of the ability of water to conduct an electric current. It is related to the total concentration of ionizable solids in the water. It is inversely proportional to electrical resistance.

Drilling Fluid: A fluid (liquid or gas) that may be used in drilling operations to remove cuttings from the borehole, to clean and cool the drill bit, and to maintain the integrity of the borehole during drilling.

Hydraulic Conductivity (k): The volume of water that will move in unit time under unit gradient through a unit area measured at right angles to the direction of flow.

Hydrologic Units: Geologic strata that can be distinguished based on the capacity to yield and transmit fluids. Aquifers and confining units are types of hydrologic units. Boundaries of a hydrologic unit may not necessarily correspond with laterally or vertically to lithostratigraphic formations.

Oil Air Filter: A filter or series of filters placed in the air-flow line from an air compressor to reduce the oil content of the air.

Oil Trap: A device used to remove oil from the compressed air discharged from an air compressor.

Riser: The pipe extending from the well screen to or above the ground surface.

Static Water Level: The elevation of the top of a column of water in a monitoring well or piezometer that is not influenced by pumping or conditions related to well installation, hydrologic testing, or nearby pumpage.

Transmissivity (T): The rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient. (Note: It is equal to an integration of the hydraulic conductivities across the saturated part of the aquifer perpendicular to the flow paths.)

Well Screen: A filtering device used to retain the annular filter pack materials; usually a cylindrical pipe with openings if a uniform width, orientation, and spacing.

Well Screen Jetting (Hydraulic Jetting): A means of well development, whereby a jetting tool comprising a perforated pipe connected to a high pressure pump, water is forced outwardly through the screen under pressure into the filter pack, and sometimes into the adjacent geologic unit.

1.4 REFERENCES

Aller, L. 1989. *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells.* National Well Water Association.

American Society for Testing and Materials (ASTM). 1989. "Proposed Recommended Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers." *Annual Book of ASTM Standards.* Philadelphia, Pennsylvania.

California Environmental Protection Agency. 1995. "Monitoring Well Design and Construction for Hydrogeologic Characterization." *Guidance for Groundwater Investigations.* July.

Driscoll, F.G. 1986. *Groundwater and Wells.* Second Edition. Johnson Division, UOP, Inc. St. Paul, Minnesota.

1.5 REQUIREMENTS AND RESOURCES

There are various options available to develop monitoring wells. The procedures and equipment required are outlined in the following sections.

2.0 PROCEDURES

Methods of well development vary with the physical characterization of hydrologic units in which the monitoring well is screened and with the drilling method used. The most common methods of well development include mechanical surging, pumping or overpumping, airlift pumping, backwashing, and jetting. These methods may be effective alone or may need to be combined (for example, mechanical surging and overpumping). Factors such as well design and hydrogeologic conditions will determine

which well development method will be the most practical and cost effective. The most common and effective methods of well development are described in Sections 2.1 to 2.2.

A well development datasheet (Attachment A) can be used to document site-specific data.

2.1 MECHANICAL SURGING

The mechanical surging method forces water to flow in and out of the well screen by operating a plunger (or surge block) or bailer in the casing, similar to a piston in a cylinder. The surge block is typically attached to a drill rod or drill stem and is of sufficient weight to cause the block to drop rapidly on the down stroke, forcing water contained in the borehole into the aquifer surrounding the well. In the recovery stroke or upstroke, water is lifted by the surge block, allowing the flow of water and fine sediments back into the well from the aquifer.

The surge block should be lowered into the well to 10 to 15 feet beneath the static water level and above the well screen, depending on the hydrologic conditions of the aquifer. The water column will effectively transmit the action of the block to the filter pack and hydrologic unit adjacent to the well screen. The initial surging action should be relatively gentle, allowing any material blocking the screen to break up, go into suspension, and then move into the well. As water begins to move easily both in and out of the screen, the surging tool is usually lowered in increments to a level just above the screen. As the block is lowered, the force of the surging movement should be increased. In wells equipped with long screens, it may be more effective to operate the surge block in the screen to concentrate its actions at various levels. Development should begin above the screen and move progressively downward to prevent the tool from becoming sand locked in the well. Periodically a pump or bailer should then be used to remove dislodged sediment that may have accumulated at the bottom of the well during the surging process.

Surging can disturb the formation and or filter pack, altering the hydraulic properties of these units. In formations with high clay and silt contents, surging can cause the screen to become clogged with fines. In all applications, surging should be used with caution to prevent casing and screen damage.

2.2 OVERPUMPING

Overpumping involves pumping the well at a rate substantially higher than it will be pumped during well purging and groundwater sampling. This method is most effective on coarse-grained formations. Overpumping is commonly implemented by using a submersible pump. In cases where the water table is less than 30 feet from the top of the casing, it is possible to overpump the well with a centrifugal pump. The intake pipe is lowered into the top of the water table and water is extracted.

Withdrawal of water from the top of the water table results in the same inflow at the screen as is achieved with a submersible pump. Either method of overpumping will induce a high velocity water flow, resulting in the flow of sand, silt, and clay into the well; clogged opening screen slots; and cleaning formation voids and fractures. The movement of these particles at high flow rates should eliminate particle movement at the lower flow rates used during well purging and sampling. The bridging of particles against the screen, because of the flow rate and direction created by overpumping, may be overcome by using mechanical surging or backwashing in conjunction with this method.

Effective overpumping involves the discharge of large amounts of groundwater. This may be a problem where groundwater extracted during well development is contaminated with hazardous constituents.

3.0 OVERALL CONSIDERATIONS

Other methods of well development are also available. For small-diameter and small-volume wells, a bailer can be used in place of a submersible pump in the overpumping method. Similarly, a bailer can be used in much the same fashion as a surge block in small-diameter wells. Wells can be backwashed by simply adding water to agitate and remove fines plugging the screen and formation.

3.1 INITIATION OF WELL DEVELOPMENT

Regardless of the well development method selected, a few considerations, which are universally applicable, should be considered. First, well development should not be initiated within 48 hours of grouting, and should be completed within 1 week of drilling. As flow is established through the intake portion of the well, the degree of agitation can be slowly increased. Second, there should be no time limit placed on well development. Well development should be considered complete when the flow is reasonably clear and free of sediment and when pH, temperature, and specific conductivity have

stabilized. This threshold should be rechecked at least once after letting the well sit undisturbed until it has achieved 95 percent water elevation recovery. These considerations are described in detail in the "Proposed Recommended Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers" (ASTM 1989).

3.2 WELL DEVELOPMENT FACTORS TO BE CONSIDERED

An important factor in any method is that the development work be started slowly and gently and that it be increased in vigor as the well is developed. Most methods of well development require the application of sufficient energy to disturb the filter pack, thereby freeing the fines and allowing them to be drawn into the well. The coarser fractions then settle around and stabilize the screen.

Development procedures for wells completed in fine sand and silt strata should involve methods that are relatively gentle, so that the strata material will not be incorporated into the filter pack. Vigorous surging for development can produce mixing of the fine strata and filter pack and produce turbid samples from the installation. In addition, development methods should be carefully selected based on the potential contaminant present, quality of wastewater generated, and requirements for containerization or treatment of wastewater.

For small-diameter and small-volume wells, a bailer can be used in place of a submersible pump in the pumping method. Similarly, a bailer can be used in small-diameter wells in much the same fashion as a surge block.

Wells can be backwashed by simply adding water to agitate and remove fines plugging the screen and formation.

Any time an air compressor is used, it should be equipped with an oil-air filter or an oil trap to minimize the introduction of oil into the screen area. The presence of oil would impact organic constituent concentrations of the water samples.

3.3 DURATION OF WELL DEVELOPMENT

Well development should begin after the monitoring well is completely installed and before water sampling begins. Development should be continued until representative water, free of the drilling fluids, cuttings, or other materials introduced during well construction, is obtained. Representative water is

assumed to have been obtained when pH, temperature, and specific conductivity readings stabilize and the water is visually clear of suspended solids. The minimum duration of well development should vary in accordance with the method used to develop the well. For example, surging and pumping the well may provide a stable, sediment free sample in a matter of minutes; whereas, bailing the well may require several hours of continuous effort to obtain a clear sample. Once the well is initially considered developed, it should be left to recover to at least 95 percent of its natural water elevation. Once this is achieved, the development procedure should be restarted and, if the physical chemical parameters used to determine well development have not changed, the well can be considered developed.

ATTACHMENT A

WELL DEVELOPMENT DATA SHEET

THE PRESIDIO TRUST

Sheet ___ of ___

WELL DEVELOPMENT DATA SHEET

BORING NO. ___________ **WELL NO.** ___________

Project/Site Name ______________________
Trust MWO No. ______________________
Date(s) of Installation ______________________
Date(s) of Development ______________________
Personnel/Company ______________________

____
Type of Rig Used ______________________

Casing Diameter/Type ______________________
Borehole Diameter ______________________
Screened Interval(s) ______________________
Total Length of Well Casing______________________
Measured Total Depth (TOC) Initial ______________
Final ______________
Initial Depth to Water
(TOC) ______________ Date ________ Time ________
Stabilized Depth to Water
(TOC) ______________ Date ________ Time ________

TECHNIQUE(S) — DEVELOPMENT EQUIPMENT TYPE/CAPACITY

____ Jetting (Airlift) ______________________
____ Surge Block ______________________
____ Bailing ______________________
____ Pumping ______________________
____ Other ______________________

FLUIDS ADDED

Lost Drilling Fluid:______________ Gallons
Lost Purge Water: ______________ Gallons
Water During Installation:______________ Gallons
Total Fluids Added: ______________ Gallons
Source of Added Water: ______________________
Sample Collected of Added Water: Y N
Sample Designation of Added Water: ______________________

PURGE VOLUME CALCULATION

Casing Volume: __________ Ft. of water
x __________ Gallons/Foot
= __________ Gallons per Single Casing Volume
Sand Pack Volume: ________ Ft. of Saturated Sand Pack
x __________Gallons/Foot (borehole diameter)
= __________ Gallons (in borehole)
\- __________ Gallons of Casing Volume
= __________ x 0.3 (Assuming porosity = 30%)
= __________ Gallons Within Sand Pack
Single Purge Volume: __________ Gallons (Casing Vol. + Sand Pack Vol. + Fluids Added)
Minimum Purge Volume: __________ Gallons
Actual Purge Volume: __________ Gallons
Volume Measured by: ______________________
Rate of Development ________ Gallons/Minute (Hour, Day)
Pumping Rate/Depth __________ @ ______ Ft. (Below Grd.)
Immiscible Phases Present: Y N Thickness ____________

Development Criteria: ______________________

Total Volume Discharged	Rate of Discharge	Time	Temp	pH	Specific* Conductance	Turbidity (NTU)	D.O., Clarity, Odor, PID Readings, Other:

Development Completed at ______________ Gallons Discharged. Date: __________ Time: ______________

Personnel: ______________________

* Specific Conductance readings temperature compensated to 25°C, if not, report temperatures at which reading obtained.

SOP APPROVAL FORM

THE PRESIDIO TRUST
ENVIRONMENTAL STANDARD OPERATING PROCEDURE

SOIL BORING LOG PREPARATION

SOP NO. 009
REVISION NO. 00

Last Reviewed: May 2000

Quality Assurance Approved

12 JAN 01
Date

1.0 BACKGROUND

The objective of logging a borehole is to document the details of the soil and rock recovered from the borehole. These details include soil type, color, grain-size variation, grain characteristics, staining, odor, moisture content, plasticity, blow counts, soil sample interval, soil recovery, and sample numbers. These data are eventually used to reconstruct the stratigraphy under the drill site. Data collected from a borehole can then be correlated with similar data from other boreholes in the region to draw geological/hydrogeological cross-sections. These sections, various soil characteristics, and additional hydrogeological data are used to prepare models to show the migration of groundwater and of any associated contaminants.

The Unified Soil Classification System (USCS) used to classify soils is based on texture and liquid limits. The system is comprised of 15 soil groups, each identified by a two-letter symbol. The major divisions within the USCS (the first letter in each two-letter symbol) denote particle size: coarse-grained soils are sands (S) and gravels (G); fine-grained soils are silts (M) and clays (C). In coarse-grained soils, the second letter in the classification refers to the grading (sorting) of the soils. Thus (W) represents clean, well-graded (poorly sorted) materials, while (P) represents clean, poorly graded (well-sorted) materials. In fine-grained soils, silts and clays are further subdivided in terms of liquid limits, with (L) indicating soils with low liquid limits and (H) representing soils with high liquid limits.

1.1 PURPOSE

The purpose of this standard operating procedure (SOP) is to ensure that all pertinent information that can be obtained from drilling a borehole is logged completely and accurately and that there is consistency in logging the information when a personnel change occurs at the drill site.

1.2 SCOPE

This SOP applies to all personnel involved in the logging of a borehole. Preprinted borehole log forms are available and all personnel involved in borehole logging will use a form to document field activities. Attachment A contains an example of a borelog form.

1.3 DEFINITIONS

Definitions of terms that relate to borehole logging are presented below. Definitions of soil types are taken from American Society of Testing Materials (ASTM) (1993).

Blow Counts: The number of blows it takes to drive the drill bit down to a certain depth, generally to 6 inches.

Unified Soil Classification System (USCS): A geotechnical soil classification in which soils are further classified into four major divisions (coarse-grained, fine-grained, organic soils, and peat). Coarse-grained soils are classified according to grain-size, whereas fine-grained soils are further classified according to plasticity characteristics. Fifteen soil types are recognized. Each is indicated by a different two-letter group symbol, such as SP, ML, and GW.

Well-Graded Sediment/Soil: An engineering term describing a soil or unconsolidated sediment consisting of particles of several or many sizes. The opposite is "poorly graded," in which soil or sediment particles are of nearly the same size. In geological literature, "well-graded" and "poorly graded" sediments or soils are referred to as "poorly sorted" and "well-sorted," respectively.

Clay: A fine-grained passing a No. 200 (75-micrometer [μm]) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry.

Gravel: Particles of rock that will pass a 3-inch (75-millimeter [mm]) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions: coarse, passes a 3-inch (75-mm) sieve and is retained on a 3/4-inch (19-mm) sieve; and fine, passes a 3/4-inch (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

Organic Clay: A clay with sufficient organic content to influence soil properties. For classification, organic clay is a soil that would be classified as clay, except that its liquid limit value after oven drying is less than 75 percent of its liquid limit value before oven drying.

Peat: A soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

Sand: Particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-μm) sieve with the following subdivisions: coarse, passes a No. 4 (4.75-mm) sieve and is retained on No. 10 (2.00-mm) sieve; medium, passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-μm) sieve; and fine, passes a No. 40 (40 (425-μm) sieve and is retained on a No. 200 (75-μm) sieve.

Silt: A fine-grained soil passing a No. 200 (75-μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry.

1.4 REFERENCES

American Geological Institute (AGI). 1972. Data Sheet. Alexandria, Virginia.

AGI. 1987. *Glossary of Geology*. Alexandria, Virginia.

American Society for Testing and Materials (ASTM). 1997. *ASTM Standards on Environmental Sampling*. Second Edition. West Conshohocken, Pennsylvania.

Fetter, C.W. 1993. *Applied Hydrogeology*. Merrill Publishing Company. Columbus, Ohio.

Holtz, R.D., and W.D. Kovacs. 1981. *An Introduction to Geotechnical Engineering*. Prentice-Hall Inc. Englewood Cliffs, New Jersey.

1.5 REQUIREMENTS AND RESOURCES

To log the borehole, one person at the drill site should be a geoscientist or someone who has knowledge of soil types and their physical characteristics. The following supplies will be required at the drill site for borehole logging:

- Clipboard
- Borehole Log Form
- Pens
- USCS Table
- Munsell Soil Chart
- Color Chart
- Hand Lens

- Pocket Knife
- Hammer
- Sample Bottles
- Ruler
- Adhesive Tape, Scissors, and Markers
- Soil Samples for Reference
- Dilute Hydrochloric Acid
- Miscellaneous Reference Charts
- Organic Vapor Monitor (OVM)
- Speedy® Moisture Measuring Unit
- Dräeger Tube
- Combustible Gas Indicator
- Work Table
- Tent or Canopy

2.0 PROCEDURES

The following sections detail the procedure for borehole logging.

2.1 GETTING ORGANIZED AT THE DRILL SITE

Borehole logging requires setting up an organized work area at the drill site that allows for inspection of the soil and collection of any samples. The work area should also maintain a clean area for writing the soil description and preparing sample containers and labels. As the borehole material is pulled up and retrieved for sampling, testing, or inspection, a variety of subtasks must be completed in a certain sequence and in a limited time span. It is important, therefore, that all of the supplies and equipment be well organized and the tasks are clearly understood by the persons who are supposed to log the borehole.

2.2 LOGGING A BOREHOLE

Preprinted borelog forms are available to ensure that pertinent information is recorded by field personnel. (A sample form is provided as Attachment A.) Borelog forms will be completed by field personnel during drilling operations.

Instructions for completing the sample form (see Attachment A) are presented below.

1. **General:** At the beginning of each day, draw a horizontal line across the log with the date and a signature to record daily drilling progress.

2. **Location Sketch:** Draw a sketch map of the borehole site in the space provided at the upper left corner of the borelog form. Mark the precise location of the borehole with an "X" and clearly label it (for example, BH-12). Also draw and label prominent features in the vicinity of the borehole, such as railroads, streets, buildings, fencelines, and other landmarks. The direction to north should be shown (N with an arrow). Give an approximate scale.

3. **MWO No., Building/Site Name, and Project Name:** Enter this information as appropriate. Print the name(s) of the person(s) who logged the segment shown on any particular page of the borelog form.

4. **Boring Number, Drilling Method, etc.:** This part of the form is self-explanatory. Enter "Sheet __ of __," on each page after the borehole is completed

5. **Sample ID:** For sample identification, the project-specific field sampling plan should be consulted to determine the correct naming.

6. **Blows/6-inch Sampler:** Record the number of blows in each 6-inch interval. If more than 100 blows are counted in the 6-inch interval, then record only 100. In this column, the hammer-weight should be entered immediately below the blow count on first entry of each day, after which the hammer-weight should be recorded only if it is changed.

7. **Drive Inverval/Recovered Interval:** Record the length of sampler driven into the soil and the length of the soil sample recovered in the sampler, in inches.

8. **Time:** Record the exact time when the sample was collected in military time (for example, 1715 hours)

9. **OVM:** Record the photoionization detector or flame ionization detector reading, in parts per million (ppm).

10. **Depth in Feet:** Enter numerals to indicate the depth as multiples of 1 or 10 feet.

11. **USCS Soil Symbol:** Enter appropriate USCS abbreviations (SW, SP, ML, etc.) based on the soil description in the next column. Complete this column only after the soil types have been described. Consult ASTM guidelines for visual classification of soils.

12. **Soil Description:** Record the soil description noting the following items: soil type, color (with code from the color chart), texture (grain size, roundness, etc.), bedding, odor, consistency (stiffness, plasticity, etc., for cohesive soils), relative density (loose, dense, etc., for granular soils), and moisture content (dry, moist, saturated, etc.). The Field Descriptions for Soil table provided in Attachment B can be used to aid in the description formulation process. Record the depth of the water table where it is encountered. The presence of the water table should be indicated by writing down "saturated at __ feet." Soil classified as "sand" should be further categorized as well-graded (SW) or poorly graded (SP). It should be remembered that the term "well-graded" in geotechnology is the opposite of "well-sorted" in geology. Record the sample media and sample tag number, as necessary.

13. **Well Construction:** Well construction details can be noted here. However, a Monitoring Well Installation Record should be completed to record all appropriate details regarding well construction (see SOP No. 004).

14. When the borehole is terminated, enter "Borehole terminated at ___ feet."

ATTACHMENT A
SAMPLE FIELD BORELOG FORM

SOIL BORING AND WELL INSTALLATION AND VISUAL CLASSIFICATION LOG

MWO No.:

Bldg./Site:

Project Name:

Time	Depth (ft) bgs	Drive Interval	Recovered Interval	Sample ID	Blow count (per 6 inches) / V.B. utility type, dia.	Description	USCS soil symbol	Well construction	OVM (ppm)

SOIL BORING AND WELL INSTALLATION AND VISUAL CLASSIFICATION LOG

MWO No.:
Bldg./Site:
Project Name:

Boring Number:	Date Started:
Drilling Method: (*Circle one*) HSA Continuous Core/GeoProbe/Hand Auger Other:	Date Completed: Logged By:
Outer Diameter of Boring:	Drilling Contractor:
Inner Diameter of Well Casing:	Driller:
Depth to Water (ft./bgs.)	Location Sketch:

Time	Depth (ft) bgs	Drive Interval	Recovered Interval	Sample ID	Blow count (per 6 inches) / V.B. utility type, dia.	Description	USCS soil symbol	Well construction	OVM (ppm)

ATTACHMENT B

FIELD DESCRIPTIONS FOR SOIL SUMMARY TABLE

FIELD DESCRIPTIONS FOR SOIL

1. TEXTURAL NAME AND PROPORTIONS OF SOIL CONSTITUENTS

Clay — Silt
Silty Clay — Sandy Silt
Clayey Silt

Silty Sand — Sandy Gravel
Sand — Gravel
Gravelly Sand

Where apparent, indicate approximate percentages of each constituent.

Trace (Minor) – 0 to 5 percent
Some – 5 to 25 percent
Abundant (clayey, silty, sandy, gravelly) – 25 to 50 percent

2. PARTICLE SIZE DISTRIBUTION OR RANGE (use to modify the textural name and describe the second major constituent)

Very Fine Sand	0.01 to 0.07 mm
Fine Sand	0.07 to 0.4 mm
Medium Sand	0.4 to 2 mm
Coarse Sand	2 to 4 mm
Very Coarse Sand	4 to 6 mm
Granule	4 to 6 mm
Gravels	6 mm to 7.5 cm
Cobbles	7.5 to 30 cm
Boulders	> 30 cm

3. COLOR

See Munsell Soil Color Chart, or GSA rock color chart

Provide name and code in parentheses

Where mottled, describe all colors present; where weathered or oxidized, modify with these colors as well

4. SORTING (use to discuss size distribution when coarser grains predominate)

Well Sorted: ~ 90 percent of particles in 1 or 2 size classes

Moderately Sorted: ~ 90 percent of particles in 3 or 4 size classes

Poorly Sorted: Unsystematic range of particles sizes; no size class predominates

Sorting = Spread of range or degree of similarity

5. PLASTICITY

Nonplastic: Soil falls apart at any water content (crumbly)

Slightly Plastic: Soil easily crushed with fingers; a thread can barely be rolled; low dry strength

Plastic: Soil difficult to crush with fingers; easily rolled thread up to the plastic limit, failure after reaching the plastic limit; medium dry strength

Very Plastic: Soil impossible to crush with fingers (highly deformable); threads require much time to reach plastic limit, and can be rerolled several times after reaching the plastic limit

Plastic Limit = Boundary between the plastic and semisolid state (an Atterberg limit)

6. MOISTURE

Dry — Moist
Slightly Moist — Wet

7. DENSITY/CONSISTENCY

DENSITY OF GRANULAR SOILS:

Very Loose — Dense
Loose — Very Dense
Moderately Dense

CONSISTENCY OF COHESIVE SOILS:

Very Soft — Stiff (firm)
Soft — Very Stiff (firm
Moderately Stiff — Hard (tight)

8. SOIL STRUCTURE

GRADE/UNIFORMITY:

Structureless (homogeneous) — Moderate
Weak — Strong

FORM:

Bedding (describe bed thickness) — Columnar
Stratified — Prismatic
Laminated — Blocky
Banded — Granular
Platy
Imbricated

8. SOIL STRUCTURE (continued)

DEFECTS IN SOIL STRUCTURE:

Slickensides — Burrows
Roots — Fissures

Cementation — Weathering (type and extent)
- salts — - fresh
- caliche — - depth of weathering
- hardpan — - color

9. MINERALOGY/ANGULARITY

Pertinent for coarse-grained constituents, including sand grains

GENERAL TERMS:	SPECIFIC TERMS:
Arkosic	Feldspar, Quartz
Felsic (light)	K-Feldspar, Quartz Plagioclase Feldspar
Mafic (dark)	Augite, Hornblende, Biotite, Pyroxene
Micaceous	Muscovite, Biotite, Phologopite
Plutonic	Granite, Monzonite, Gabbro
Volcanic	Rhyolite, Latite, Basalt
Oxidized	FeO_2, Limonite
Rock Fragments	

ANGULARITY/SHAPE:

Angular — Subrounded
Subangular — Rounded
Flat — Elongated

10. DESCRIPTION OF SECOND MAJOR CONSTITUENT IF APPLICABLE

Refer to horizon boundaries

11. HORIZON BOUNDARY

GENERAL TERMS:	SPECIFIC TERMS:
Gradational	Abrupt
Sharp	Diffuse
Erosional	Smooth
Depositional	Wavy
	Irregular
	Broken

12. ENVIRONMENT

GENERAL TERMS:	SPECIFIC TERMS (DEPOSITS):
Fill Material	Point Bar
Alluvium	Overbank
Colluvium	Channel
Detritus	Turbidity
Lateritic	Alluvial Fan
Landfilll Material	Eolian
	Marine/bay
	Lagoonal
	Deltaic

13. ADDITIONAL INFORMATION

SAMPLING DESIGNATIONS:
For soil or groundwater samples collected from borehole, including direct-push methods

USCS SOIL TYPE

PID READINGS (where taken):
Borehole/headspace/direct sample reading

DRILLING INFORMATION:
Drilling rate/progress

Terminology
- tight - smooth - chattering

Fluid Type/Fluid Loss
- intervals of loss
- quantity lost

Changes in drilling methods

Explanation of downtime

PHOTOGRAPHIC INFORMATION:
Photo number and description, date, time, photographer

GROUNDWATER INFORMATION:
Initial depth of water
Stabilized depth to water

MISCELLANEOUS INFORMATION:
Borehole to be converted to monitoring well, weather conditions

EXAMPLE DESCRIPTIONS:

(1) Silty clay, about equal silt/clay, mottled olive (5 YR 5/3) to yellowish brown (10 YR 5/6), nonplastic (crumbly), dry, dense, with 1 to 20 mm granules and a 2 to 5 cm lens of coarse quartz sand and gravel, gravels are 3 to 4 mm, rounded, crystalline hard siltstone, sharp contract with GC below, probable fill material, OVM = 0.1 (open sample).

(2) Clay or silty clay with abundant gravel (about 50 percent), medium to large pebbles (1 to 2.5 cm), well sorted, subrounded, arkosic; clay/silt hard to distinguish, stained dark gray (10 YR 4/1) to gray (10 YR 5/1) with hydrocarbons, slightly plastic, slightly moist, moderately stiff, uniform, sparse mica or sericite, occasional shell fragments, intertidal marine silts/clays; headspace readings 15-25 ppm; photo #29, stained soils in open split spoon, 10/5/90, 1430, D. West; Sample TP-4 (10-11.5) collected.

SOP APPROVAL FORM

THE PRESIDIO TRUST

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

LOCATION SURVEY

SOP NO. 013

REVISION NO. 00

Last Reviewed: December 2000

Quality Assurance Approved

14 JAN 01

Date

1.0 BACKGROUND

Sampling locations for data intended to be entered into the Trust database, including monitoring wells, soil borings, or surface sample locations for soil, water or air, used or installed during field investigations will generally need to be properly surveyed. Proper survey of sample locations allows for accurate presentation of information stored in databases. In addition, it is important to properly survey sampling locations in the event that the location(s) needs to be relocated. Other features specific to a site, for example, utilities, buildings, surface cover types, or types of vegetation can also be surveyed. Each field measurement should be traceable to the person collecting the measurement, the field equipment used, date and time, and any calibration and field records, so that procedures can be retraceable. Two survey methods, traditional and Global Positioning System (GPS) may be used to survey sample locations or various site features during field investigations. The site sampling plan will specify which of the two methods will be used.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements for appropriately surveying sample locations and additional site data (for example, utilities, buildings, surface cover types, and types of vegetation).

1.2 SCOPE

This SOP applies to all sample locations. If collection of additional site feature information (for example, utilities, buildings, surface cover types, and types of vegetation) is required, this SOP applies as well.

1.3 DEFINITIONS

Global Positioning System (GPS): GPS provides specially coded satellite signals, which can be processed in a GPS receiver, enabling the receiver to compute position, velocity, and time.

Traditional Survey: Determination of horizontal coordinates utilizing horizontal angle or direction measurements and calculated horizontal distances through a process of triangulation, and of horizontal line of sight.

1.4 REFERENCES

U.S. Environmental Protection Agency (EPA). 1996. "Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM)." Region 4 Science and Ecosystem Support Division Enforcement and Investigations Branch. May. Includes 1997 Revisions.

1.5 REQUIREMENTS AND RESOURCES

Traditional survey and GPS equipment that are necessary to perform location surveys include the following:

- Topcon GTS-2, total station theodolite/electronic distance meter (or equivalent)
- Trimble Pathfinder Pro XL 8 channel or 12 channel GPS receiver
- Tripod(s)
- Reflector prism(s)
- Prism pole
- Steel tape
- Cloth tape
- Right angle prism
- Compass

2.0 PROCEDURES

Coordinates in the horizontal plane shall be surveyed for all sampling locations using either GPS or traditional survey methods. Vertical elevations shall be surveyed at all monitoring wells and other sample locations where vertical accuracy is required.

Prior to conducting the survey, all sampling locations and other desired site feature information should be clearly identified and marked with and identification name or number (ID). The surveyor should be provided with a list and a sketch map of all sampling locations and site features requiring surveying. The list should include the sampling locations IDs.

The location of wells, borings, and sampling locations should be surveyed by a California Registered civil engineer or a California licensed professional surveyor if the associated data will be incorporated into the Presidio database. The horizontal position of the sample locations should be measured relative to the 1927 North American Datum (NAD27), State Plan Coordinate System, California Zone III to an accuracy of plus or minus 0.1 feet. Vertical elevations will be surveyed to an accuracy of plus or minus 0.01 feet relative to the 1907 Presidio lower low water (PLLW) vertical datum or the 1929 National Geodetic Vertical Datum (NGVD29), based on the historic preference at the particular site. The PLLW datum will be used when no vertical datum has been established at a site

Monitoring well elevations should be surveyed at the ground surface and at the top of the well casing. A permanent reference point such as a notch cut in the well casing should mark the survey point. In addition, a height of a reference survey datum should be permanently marked on top of the inner well casing. Because the well casing is less susceptible to disturbance (such as collision), the surveyed reference mark should be placed on the top of the well casing for use as a measuring point, not on the protective casing or the well apron. The survey should also note the coordinates of any temporary benchmarks. The reference marked on top of inner well casings should be resurveyed at least once every 5 years, unless anomalous ground water head data appear or damage to the well casing or protective completion is noted. These cases may require that well casings be resurveyed on a more frequent basis.

Results, including northing, easting, elevation, sample location ID, and date and time, for each location surveyed should be reported in a hard copy and electronic format.

SOP APPROVAL FORM

THE PRESIDIO TRUST

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

GENERAL EQUIPMENT DECONTAMINATION

SOP NO. 014

REVISION NO. 00

Last Reviewed: December 2000

Quality Assurance Approved

12 Jan 01

Date

1.0 BACKGROUND

All nondisposable field equipment must be decontaminated before and after each use at each sampling location to obtain representative samples and to reduce the possibility of cross-contamination.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for decontaminating equipment in the field.

1.2 SCOPE

This SOP applies to decontaminating general nondisposable field equipment. To prevent contamination of samples, all sampling equipment must be thoroughly cleaned prior to each use.

1.3 DEFINITIONS

Nonphosphate soap: Alconox® and Liquinox® are common laboratory grade products

1.4 REFERENCES

U.S. Environmental Protection Agency (EPA). 1992. "RCRA Groundwater Monitoring: Draft Technical Guidance." Office of Solid Waste and Emergency Response. Washington, DC. EPA/530-R-93-001. November.

EPA. 1994. "Sampling Equipment Decontamination." Environmental Response Team SOP No. 2006. Revision No. 0.0. August 11. (On-Line Address: http://www.ert.org/media_resrcs/media_resrcs.asp.)

1.5 REQUIREMENTS AND RESOURCES

The equipment required to conduct decontamination is as follows:

- Scrub brushes
- Large wash tubs or buckets
- Squirt bottles
- Nonphosphate soap
- Tap water

- Distilled water
- Plastic sheeting
- Aluminum foil
- Methanol or hexane
- Dilute (0.1 N) nitric acid
- Steam cleaner

2.0 PROCEDURES

The procedures below discuss decontamination of personal protective equipment (PPE), drilling and monitoring well installation equipment, borehole soil sampling equipment, water-level measurement equipment, and general sampling equipment.

2.1 PERSONAL PROTECTIVE EQUIPMENT DECONTAMINATION

Personnel working in the field are required to follow specific procedures for decontamination prior to leaving the work area so that contamination is not spread off-site or to clean areas. All used disposable protective clothing, such as Tyvek® coveralls, gloves, and booties, will be containerized for later disposal. Decontamination water will be containerized in 55-gallon drums.

Personnel decontamination procedures will be as follows:

1. Wash neoprene boots (or neoprene boots with disposable booties) with Liquinox or Alconox solution and rinse with clean water. Remove booties and retain boots for subsequent reuse.
2. Wash outer gloves in Liquinox® or Alconox® solution and rinse in clean water. Remove outer gloves and place into plastic bag for disposal.
3. Remove Tyvek® or coveralls. Containerize Tyvek® for disposal and place coveralls in plastic bag for reuse.
4. Remove air purifying respirator (APR), if used, and place the spent filters into a plastic bag for disposal. Filters should be changed daily or sooner depending on use and application. Place respirator into a separate plastic bag after cleaning and disinfecting.
5. Remove disposable gloves and place them in plastic bag for disposal.
6. Thoroughly wash hands and face in clean water and soap.

2.2 DRILLING AND MONITORING WELL INSTALLATION EQUIPMENT DECONTAMINATION

All drilling equipment should be decontaminated before drilling operations begin, between borings, and at completion of the project. The locations for decontamination activities will be designated by the Trust project manager.

Monitoring well casing, screens, and fittings are assumed to be delivered to the site in a clean condition. However, they should be steam cleaned on-site prior to placement downhole. The drilling subcontractor will typically furnish the steam cleaner and water.

After cleaning the drilling equipment, field personnel should place the drilling equipment, well casing and screens, and any other equipment that will go into the hole on clean polyethylene sheeting. The drilling auger, bits, drill pipe, temporary casing, surface casing, and other equipment should be decontaminated by the drilling subcontractor by hosing down with a steam cleaner until thoroughly clean. Drill bits and tools that still exhibit particles of soil after the first washing should be scrubbed with a wire brush and then rinsed again with a high-pressure steam rinse.

All wastewater from decontamination procedures should be containerized.

2.3 BOREHOLE SOIL SAMPLING EQUIPMENT DECONTAMINATION

The soil sampling equipment should be decontaminated after each sample as follows:

1. Prior to sampling, scrub the split-barrel sampler and sampling tools in a bucket, containing Liquinox® or Alconox® solution, using a stiff, long bristle brush.
2. Steam clean the sampling equipment over the rinsate tub and allow to air dry or rinse with deionized (distilled) water.
3. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.
4. Containerize all water and rinsate.
5. Decontaminate all pipe placed down the hole as described for drilling equipment.

2.4 WATER-LEVEL MEASUREMENT EQUIPMENT DECONTAMINATION

Field personnel should decontaminate the well sounder and interface probe before inserting and after removing them from each well. The following decontamination procedures should be used:

1. Wipe the sounding cable with a disposable soap-impregnated cloth or paper towel.
2. Rinse with deionized (distilled) organic-free water.

2.5 GENERAL SAMPLING EQUIPMENT DECONTAMINATION

All nondisposable sampling equipment should be decontaminated using the following procedures:

1. Select an area removed from sampling locations that is both downwind and downgradient. Decontamination must not cause cross-contamination between sampling points.
2. Maintain the same level of protection as was used for sampling.
3. If a steam cleaner is not available, to decontaminate a piece of equipment, use an Alconox® wash; a tap water wash; a solvent (methanol or hexane) rinse, if applicable or dilute (0.1 N) nitric acid rinse, if applicable; a distilled water rinse; and air drying. Use a solvent (methanol or hexane) rinse for grossly contaminated equipment (for example, equipment that is not readily cleaned by the Alconox® wash). The dilute nitric acid rinse may be used if metals are the analyte of concern.
4. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.
5. Containerize all water and rinsate.

SOP APPROVAL FORM

THE PRESIDIO TRUST
ENVIRONMENTAL STANDARD OPERATING PROCEDURE

PACKAGING AND SHIPPING SAMPLES

SOP NO. 015

REVISION NO. 00

Last Reviewed: December 2000

Quality Assurance Approved

12 Jan 01
Date

1.0 BACKGROUND

In any sampling program, the integrity of a sample must be ensured from its point of collection to its final disposition. Procedures for classifying, packaging, and shipping samples are described below. Steps in the procedures should be followed to ensure sample integrity and to protect the welfare of persons involved in shipping and receiving samples. When hazardous substances and dangerous goods are sent by common carrier, their packaging, labeling, and shipping are regulated by the U.S. Department of Transportation (DOT) Hazardous Materials Regulations (HMR) (*Code of Federal Regulations*, Title 49 [49 CFR] Parts 106 through 180) and the International Air Transportation Association (IATA) Dangerous Goods Regulations (DGR).

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for packaging and shipping samples. It has been prepared in accordance with the U.S. Environmental Protection Agency (EPA) "Sampler's Guide to the Contract Laboratory Program (CLP)," the DGR, and the HMR. Sample packaging and shipping procedures described in this SOP should be followed for all sample packaging and shipping. Deviations from the procedures in this SOP must be documented in a field logbook. This SOP assumes that samples are already collected in the appropriate sample jars and that the sample jars are labeled and tagged appropriately.

1.2 SCOPE

This SOP applies to sample classification, packaging, and shipping.

1.3 DEFINITIONS

Chain of Custody: Document indicating custody of the samples at all times between sampling and analysis.

Custody Seal: A custody seal is a tape-like seal. Placement of the custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been packaged for shipping.

Dangerous Goods: Dangerous goods are articles or substances that can pose a significant risk to health, safety, or property when transported by air; they are classified as defined in Section 3 of the DGR (IATA 1999).

Environmental Samples: Environmental samples include drinking water, groundwater and surface water, soil, sediment, treated municipal and industrial wastewater effluent, and biological specimens. Environmental samples typically contain low concentrations of contaminants and when handled require only limited precautionary procedures.

Hazardous Materials Regulations: The HMRs are DOT regulations for the shipment of hazardous materials by air, water, and land; they are located in 49 CFR 106 through 180.

Hazardous Samples: Hazardous samples include dangerous goods and hazardous substances. Hazardous samples shipped by air should be packaged and labeled in accordance with procedures specified by the DGR; ground shipments should be packaged and labeled in accordance with the HMR.

Hazardous Substance: A hazardous substance is any material, including its mixtures and solutions, that is listed in Appendix A of 49 CFR 172.101 and its quantity, in one package, equals or exceeds the reportable quantity (RQ) listed in the appendix.

IATA Dangerous Goods Regulations: The DGRs are regulations that govern the international transport of dangerous goods by air. The DGRs are based on the International Civil Aviation Organization (ICAO) Technical Instructions. The DGR contain all of the requirements of the ICAO Technical Instructions and are more restrictive in some instances.

Nonhazardous Samples: Nonhazardous samples are those samples that do not meet the definition of a hazardous sample and **do not** need to be packaged and shipped in accordance with the DGR or HMR.

Overpack: An enclosure used by a single shipper to contain one or more packages and to form one handling unit (IATA 1999). For example, a cardboard box may be used to contain three fiberboard boxes to make handling easier and to save on shipping costs.

1.4 REFERENCES

U.S. Department of Transportation, Transport Canada, and the Secretariat of Communications and Transportation of Mexico (DOT and others). 1996. *1996 North American Emergency Response Guidebook.*

International Air Transport Association (IATA). 1997. *Guidelines for Instructors of Dangerous Courses.*

IATA. 1999. *Dangerous Goods Regulations.* 40th Edition.

U.S. Environmental Protection Agency. 1994. "Sampler's Guide to the Contract Laboratory Program." Office of Solid Waste and Emergency Response. Washington, DC. EPA/540/R-96/032. On-Line Address: http://www.epa.gov/oerrpage/superfund/programs/clp/guidance.htm - sample

1.5 REQUIREMENTS AND RESOURCES

The procedures for packaging and shipping **nonhazardous** samples require the following:

- Coolers
- Ice
- Vermiculite, bubble wrap, or similar cushioning material
- Chain-of-custody forms and seals
- Airbills
- Resealable plastic bags for sample jars and ice
- Tape (strapping and clear)

The procedures for packaging and shipping **hazardous** samples require the following:

- Ice
- Vermiculite or other noncombustible, absorbent packing material
- Chain-of-custody forms and seals
- Appropriate dangerous goods airbills and emergency response information to attach to the airbill
- Resealable plastic bags for sample jars and ice

- Tape (strapping and clear)
- Appropriate shipping containers, as specified in the DGR
- Labels that apply to the shipment such as hazard labels, address labels, "Cargo Aircraft Only" labels, and package orientation labels (up arrows)

2.0 PROCEDURES

The following procedures apply to packing and shipping nonhazardous and hazardous samples.

2.1 SAMPLE CLASSIFICATION

Prior to sample shipment by air courier, it must be determined whether the sample is subject to the DGR. Samples subject to these regulations shall be referred to as hazardous samples. Any airline belonging to IATA must follow the DGR. As a result, these air carriers **may not** accept a shipment that is packaged and labeled in accordance with the HMR (although in most cases, the packaging and labeling would be the same for either set of regulations). The HMR states that a hazardous material may be transported by aircraft in accordance with the ICAO Technical Instruction (49 CFR 171.11) upon which the DGR is based. Therefore, the use of the DGR for samples to be shipped by air complies with the HMR, but not vice versa.

Most environmental samples are not hazardous samples and do not need to be packaged in accordance with any regulations. Hazardous samples are those samples that can be classified as specified in Section 3 of the DGR, can be found in the List of Dangerous Goods in the DGR in bold type, are considered a hazardous substance (see definition), or are mentioned in "Section 2 - Limitations" of the DGR for countries of transport or airlines (such as FedEx). The hazard classifications specified in the DGR (and the HMR) are as follows:

Class 1 – Explosives

Division 1.1 – Articles and substances having a mass explosion hazard
Division 1.2 – Articles and substances having a projection hazard but not a mass explosion hazard
Division 1.3 – Articles and substances having a fire hazard, a minor blast hazard, and/or a minor projection hazard but not a mass explosion hazard
Division 1.4 – Articles and substances presenting no significant hazard
Division 1.5 – Very sensitive substances mass explosion hazard

Division 1.6 – Extremely insensitive articles, which do not have a mass explosion hazard

Class 2 – Gases

Division 2.1 – Flammable gas
Division 2.2 – Nonflammable, nontoxic gas
Division 2.3 – Toxic gas

Class 3 – Flammable Liquids

Class 4 – Flammable Solids; Substances Liable to Spontaneous Combustion; Substances, when in Contact with Water, Emit Flammable Gases

Division 4.1 – Flammable solids
Division 4.2 – Substances liable to spontaneous combustion
Division 4.3 – Substances, when in contact with water, emit flammable gases

Class 5 – Oxidizing Substances and Organic Peroxide

Division 5.1 – Oxidizers
Division 5.2 – Organic peroxides

Class 6 – Toxic and Infectious Substances

Division 6.1 – Toxic substances
Division 6.2 – Infectious substances

Class 7 – Radioactive Material

Class 8 – Corrosives

Class 9 – Miscellaneous Dangerous Goods

The criteria for each of the first eight classes are very specific and are outlined in Section 3 of the DGR and 49 CFR 173 of the HMR. Some classes and divisions are further divided into packing groups based on their level of danger. Packing group I indicates a great danger, packing group II indicates a medium danger, and packing group III indicates a minor danger. Class 2, gases, includes any compressed gas being shipped and any noncompressed gas that is either flammable or toxic. A compressed gas is defined as having a pressure over 40 pounds per square inch (psi) absolute (25 psi gauge). Most air samples and empty cylinders that did not contain a flammable or toxic gas are exempt from the regulations. An empty hydrogen cylinder, as in a flame ionization detector (FID), is considered a dangerous good unless it is properly purged with nitrogen in accordance with the HMR. A landfill gas sample is usually considered a

flammable gas because it may contain a high percentage of methane. Class 3, flammable liquids, are based on the boiling point and flash point of a substance. Most class 3 samples include solvents, oil, gas, or paint-related material collected from drums, tanks, or pits. Division 6.1, toxic substances, is based on oral toxicity (LD_{50} [lethal dose that kills 50 percent of the test animals]), dermal toxicity (LD_{50} values), and inhalation toxicity (LC_{50} [lethal concentration that kills 50 percent of the test animals] values). Division 6.1 substances include pesticides and cyanide. Class 7, radioactive material, is defined as any article or substance with a specific activity greater than 70 kiloBecquerels (kBq/kg) (0.002 [microCuries per gram [μCi/g]). If the specific activity exceeds this level, the sample should be shipped in accordance with Section 10 of the DGR. Class 8, corrosives, is based on the rate at which a substance destroys skin tissue or corrodes steel; they are not based on pH. Class 8 materials include the concentrated acids used to preserve water samples. Preserved water samples are not considered class 8 substances and should be packaged as nonhazardous samples. Class 9, miscellaneous dangerous goods, is substances that present a danger, but are not covered by any other hazard class. Examples of class 9 substances include asbestos, polychlorinated biphenyls (PCB), and dry ice.

Unlike the DGR, the HMR includes combustible liquids in hazard class 3. The definition of a combustible liquid is specified in 49 CFR 173.120 of the HMR. The HMR has an additional class, ORM-D, which is not specified in the DGR. "ORM-D material" refers to a material such as a consumer commodity, which although otherwise subject to the HMR, presents a limited hazard during transport due to its form, quantity, and packaging. It must be a material for which exceptions are provided in the table of 49 CFR 172.101. The DGR lists consumer commodities as a class 9 material.

In most instances, the hazard of a material sampled is unknown because no laboratory testing has been conducted. A determination as to the suspected hazard of the sample must be made using knowledge of the site, field observations, field tests, and other available information.

According to 40 CFR 261.4(d) and (e), samples transported to a laboratory for testing or treatability studies, including samples of hazardous wastes, are **not** hazardous wastes. Air carriers will not accept a shipment of hazardous waste.

2.2 PACKAGING NONHAZARDOUS SAMPLES

Nonhazardous samples, after being appropriately containerized, labeled, and tagged, should be packaged in the following manner.

1. Place the sample in a resealable plastic bag.

2. Place the bagged sample in a cooler and pack it to prevent breakage.

3. Prevent breakage of bottles during shipment by either wrapping the sample container in bubble wrap, or lining the cooler with a noncombustible material such as vermiculite. Vermiculite is especially recommended because it will absorb any free liquids inside the cooler. It is recommended that the cooler be lined with a large plastic garbage bag before samples, ice, and absorbent packing material are placed in the cooler.

4. Add a sufficient quantity of ice to the cooler to cool samples to 4 °C. Ice should be double bagged in resealable plastic bags to prevent the melted ice from leaking out. As an option, a temperature blank (a sample bottle filled with distilled water) can be included with the cooler.

5. Seal the completed chain-of-custody forms in a plastic bag and tape the plastic bag to the inside of the cooler lid.

6. Tape any instructions for returning the cooler to the inside of the lid.

7. Close the lid of the cooler and tape it shut by wrapping strapping tape around both ends and hinges of the cooler at least once. Tape shut any drain plugs on the cooler.

8. Place two signed custody seals on the cooler, ensuring that each one covers the cooler lid and side of the cooler. Place clear plastic tape over the custody seals.

9. Place address labels on the outside of the cooler, if samples are to be shipped by a commercial carrier.

2.2 PACKAGING HAZARDOUS SAMPLES

Packaging of hazardous samples should only be performed by individuals with DOT shipping training. The procedures for packaging hazardous samples are summarized below. Note that according to the DGR, all spellings must be exactly as they appear in the List of Dangerous Goods, and only approved abbreviations are acceptable. The corresponding HMR regulations are provided in parentheses following any DGR references. The HMR must be followed only if shipping hazardous samples by ground transport.

1. Determine the proper shipping name for the material to be shipped. All proper shipping names are listed in column B of the List of Dangerous Goods table in Section 4 of the DGR (or column 2 of the Hazardous Materials Table in 49 CFR 172.101). In most instances, a generic name based on the hazard class of the material is appropriate. For example, a sample of an oily liquid collected from a drum with a high photoionization detector (PID) reading should be packaged as a flammable liquid. The proper shipping name chosen for this sample would be "flammable liquid, n.o.s." The abbreviation "n.o.s." stands for "not otherwise specified" and is used for generic shipping names. Typically, a specific name, such as acetone, should be inserted in parentheses after most n.o.s. descriptions. However, a technical name is not required when shipping a sample for testing purposes and the components are not known. If shipping a hazardous substance (see definition), then the letters "RQ" must appear in front of the proper shipping name.

2. Determine the United Nations (UN) identification number, class or division, subsidiary risk if any, required hazard labels, packing group, and either passenger aircraft or cargo aircraft packing instructions based on the quantity of material being shipped in one package. This information is provided in the List of Dangerous Goods (or Hazardous Materials Table in 49 CFR 172.101) under the appropriate proper shipping name. A "Y" in front of a packing instruction indicates a limited quantity packing instruction. If shipping dry ice or a limited quantity of a material, then UN specification shipping containers do not need to be used.

3. Determine the proper packaging required for shipping the samples. Except for limited quantity shipments and dry ice, these UN specification packages have been tested to meet the packing group of the material being shipped. Specific testing requirements of the packages are listed in Section 6 of the DGR (or 49 CFR 178 of the HMR). All UN packages are stamped with the appropriate UN specification marking. Prior planning is required to have the appropriate packages on hand during a sampling event where hazardous samples are anticipated. Most samples can be shipped in either a 4G fiberboard box, a 1A2 steel drum, or a 1H2 plastic drum. Drums can be purchased in 5- and 20-gallon sizes and are ideal for shipping multiple hazardous samples. When FedEx is used to ship samples containing PCBs, the samples must be shipped in an inner metal packaging (paint can) inside a 1A2 outer steel drum. This method of packaging PCB samples is in accordance with FedEx variation FX-06, listed in Section 2 of the DGR.

4. Place each sample jar in a separate resealable plastic bag. Some UN specification packages contain the sample jar and plastic bag to be used when shipping the sample.

5. Place each sealed bag inside the approved UN specification container (or other appropriate container if a limited quantity or dry ice) and pack with enough noncombustible, absorbent, cushioning material (such as vermiculite) to prevent breakage and to absorp liquid.

6. Place chain-of-custody forms in a resealable plastic bag and either attach it to the inside lid of the container or place it on top inside the container. Place instructions for returning the container to the shipper on the inside lid of the container as appropriate. Close and seal the shipping container in the manner appropriate for the type of container being used.

7. Label and mark each package appropriately. All irrelevant markings and labels need to be removed or obliterated. All outer packaging must be marked with proper shipping name, UN identification number, and name and address of the shipper and the recipient. For carbon dioxide, solid (dry ice), the net weight of the dry ice within the package needs to be marked on the outer package. For limited quantity shipments, the words "limited quantity" or "LTD. QTY." must be marked on the outer package. Affix the appropriate hazard label to the outer package. If the material being shipped contains a subsidiary hazard, then a subsidiary hazard label must also be affixed to the outer package. The subsidiary hazard label is identical to the primary hazard label except that the class or division number is not present. It is acceptable to obliterate the class or division marking on a primary hazard label and use it as the subsidiary hazard label. If using cargo aircraft only packing instructions, then the "Cargo Aircraft Only" label must be used. Package orientation labels (up arrows) must be placed on opposite sides of the outer package. Figure 1 depicts a properly marked and labeled package.

8. If using an overpack (see definition), mark and label the overpack and each outer packaging within the overpack as described in step 7. In addition, the statement "INNER PACKAGES COMPLY WITH PRESCRIBED SPECIFICATIONS" must be marked on the overpack.

9. Attach custody seals, and fill out the appropriate shipping papers as described in Section 2.4.

2.4 SHIPPING PAPERS FOR HAZARDOUS SAMPLES

A "Shippers Declaration for Dangerous Goods" and "Air Waybill" must be completed for each shipment of hazardous samples. Air carriers generally supply a their own Dangerous Goods Airbill to their customers; the airbill typically combines both the declaration and the waybill. An example of a completed Dangerous Goods Airbill is depicted in Figure 2. A shipper's declaration must contain the following:

- Name and address of shipper and recipient
- Air waybill number (not applicable to the HMR)
- Page ___ of ___
- Deletion of either "Passenger and Cargo Aircraft" or "Cargo Aircraft Only," whichever does not apply
- Airport or city of departure
- Airport or city of destination
- Deletion of either "Non-Radioactive" or "Radioactive," which ever does not apply

- The nature and quantity of dangerous goods. This includes the following information in the following order (obtained from the List of Dangerous Goods in the DGR): proper shipping name, class or division number, UN identification number, packing group number, subsidiary risk, quantity in liters or kilograms (kg), type of packaging used, packing instructions, authorizations, and additional handling information. Authorizations include the words "limited quantity" or "LTD. QTY." if shipping a limited quantity, any special provision numbers listed in the List of Dangerous Goods in the DGR, and the variation "USG-14" when a technical name is required after the proper shipping name but not entered because it is unknown.

- Signature for the certification statement

- Name and title of signatory

- Place and date of signing certification

- A 24-hour emergency response telephone number for use in the event of an incident involving the dangerous good

- Emergency response information attached to the shipper's declaration. This information can be in the form of a material safety data sheet or the applicable North American Emergency Response Guidebook (NAERG; DOT 1996) pages. Figure 3 depicts the appropriate NAERG emergency response information for "Flammable liquids, n.o.s." as an example.

Note that dry ice does not require an attached shipper's declaration. However, the air waybill must include the following on it: "Dry ice, 9, UN1845, ____ x ____ kg." The blanks must include the number of packages and the quantity in kg in each package. If using FedEx to ship dry ice, the air waybill includes a box specifically for dry ice. Simply check the appropriate box and enter in the number of packages and quantity in each package.

The HMR requirements for shipping papers are located in 49 CFR 172 Subpart C.

3.0 POTENTIAL PROBLEMS

The following potential problems may occur during sample shipment:

- Leaking package. If a package leaks, the carrier may open the package, return the package, and if a dangerous good, inform the Federal Aviation Administration (FAA), which can result in fines.

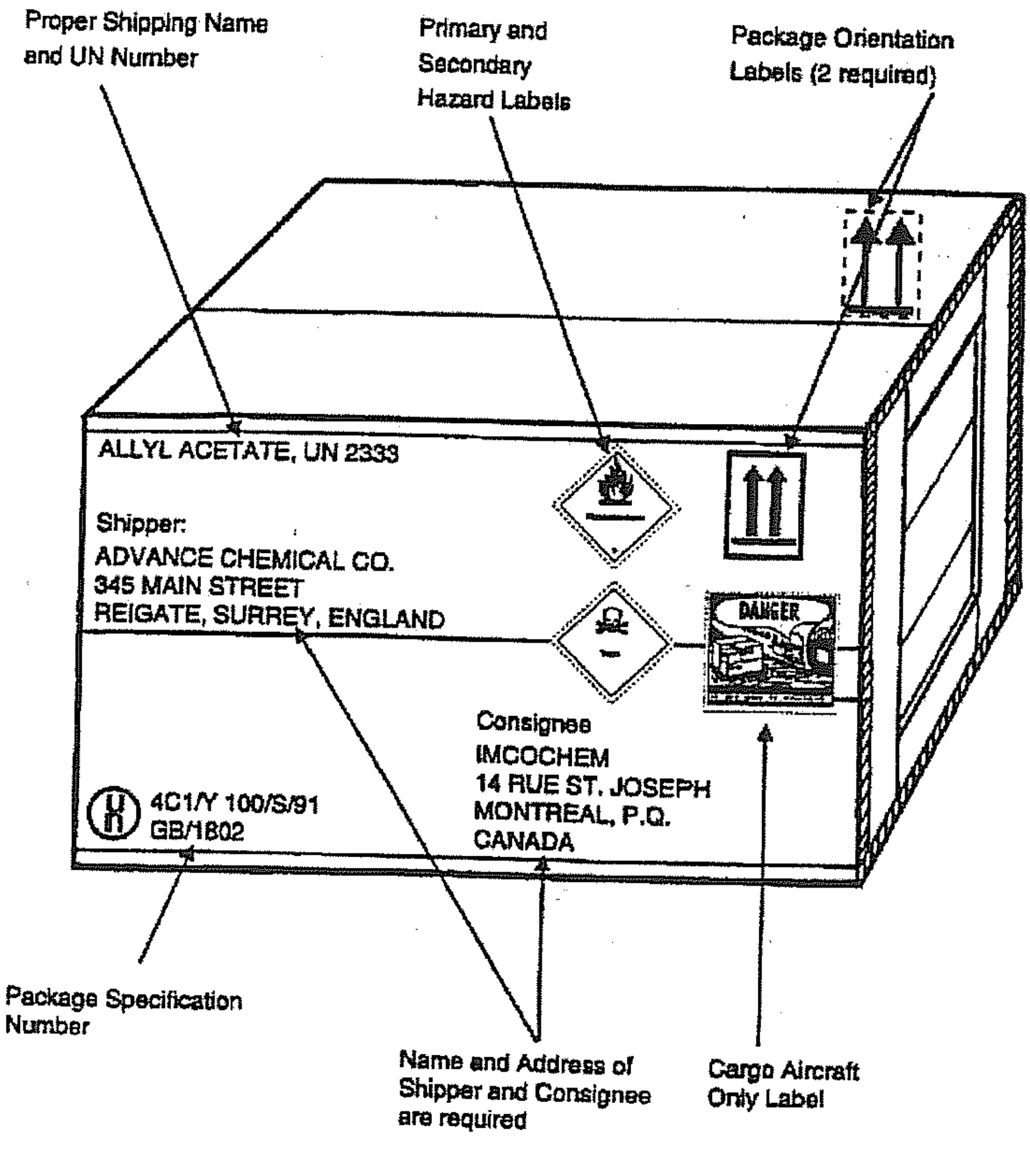
- Improper labeling and marking of package. If mistakes are made in labeling and marking the package, the carrier will most likely notice the mistakes and return the package to the shipper, thus delaying sample shipment.

- Improper, misspelled, or missing information on the shipper's declaration. The carrier will most likely notice this as well and return the package to the shipper.

Contact the air carrier with questions about dangerous goods shipments and ask for a dangerous goods expert.

FIGURE 1

EXAMPLE OF A CORRECTLY MARKED AND LABELED DANGEROUS GOODS PACKAGE



Source: International Air Transport Association (IATA). 1997.

FIGURE 2

EXAMPLE OF A DANGEROUS GOODS AIRBILL

FedEx *Dangerous Goods Airbill* — Senders Copy

The World On Time.

1 From
Date: FILL IN — Sender's FedEx Account Number: 1788-8C14-4
Sender's Name: FILL IN — Phone: (312) 856 8700
Company: TETRA TECH EM INC
Address: 200 E RANDOLPH ST STE 4700
City: CHICAGO — State: IL — ZIP: 60601

2 Your Internal Billing Reference: FILL IN

3 To
Recipient's Name / Phone / Company / Address / City / State / ZIP: FILL IN

For HOLD at FedEx Location check here: Hold Weekday / Hold Saturday
For WEEKEND Delivery check here: Saturday Delivery / Sunday Delivery

4a Express Package Service
[X] FedEx Priority Overnight — FedEx Standard Overnight — FedEx 2Day — FedEx Express Saver

4b Express Freight Service
FedEx 1Day Freight — FedEx 2Day Freight — FedEx 3Day Freight

Questions? Call 1-800-Go-FedEx (800-463-3339)

5 Packaging
[X] Other Packaging

6 Special Handling
[X] Dangerous Goods as per attached Shipper's Declaration — Cargo Aircraft Only

7 Payment
Bill to: [X] Sender — Recipient — Third Party — Credit Card — Cash/Check

Total Packages — Total Weight — Total Declared Value: $ .00

Signature Release Unavailable

374

FedEx Tracking Number: 813350883058 — 0204

Page 1 of 1 Pages

Two completed and signed copies of this Declaration must be handed to the operator.

WARNING
Failure to comply in all respects with the applicable Dangerous Goods Regulations may be in breach of the applicable law, subject to legal penalties. This Declaration must not, in any circumstances, be completed and/or signed by a consolidator, a forwarder or an IATA cargo agent.

TRANSPORT DETAILS
This shipment is within the limitations prescribed for: ~~PASSENGER AND CARGO AIRCRAFT~~ / CARGO AIRCRAFT ONLY
Airport of Departure: Chicago
Airport of Destination: "City sending sample to"

Shipment type: NON-RADIOACTIVE / ~~RADIOACTIVE~~

NATURE AND QUANTITY OF DANGEROUS GOODS

Proper Shipping Name	Class or Division	UN or I.D. No.	Packing Group	Subsidiary Risk	Quantity and Type of Packaging	Packing Inst.	Authorization
Flammable liquid, n.o.s.	3	UN 1993	III	—	4 glass jars in a 1A2 steel drum Net Quantity = 4 L	309	A3 USG-14

Additional Handling Information: NAERG # 128 Attached.

Prepared for AIR TRANSPORT according to: (Customer MUST check one) 49 CFR — [X] ICAO/IATA

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name and are classified, packaged, marked, and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations.

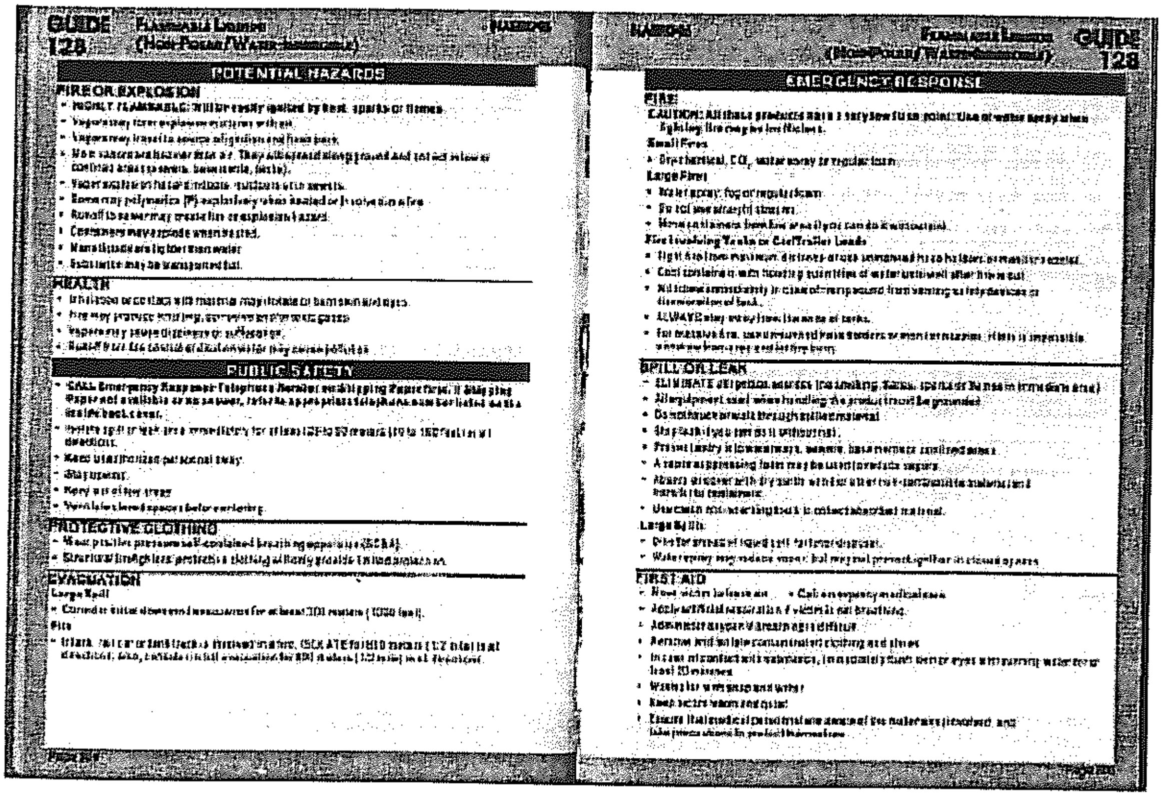
Emergency Telephone Number: FILL IN

Name/Title of Signatory: Me, Environmental Scientist
Place and Date: 200 E Randolph, Chicago, IL xx/xx/xx
Signature: Me

IF ACCEPTABLE FOR PASSENGER AIRCRAFT, THIS SHIPMENT CONTAINS RADIOACTIVE MATERIAL INTENDED FOR USE IN, OR INCIDENT TO, RESEARCH, MEDICAL DIAGNOSIS, OR TREATMENT.

FIGURE 3

NAERG EMERGECY RESPONSE INFORMATION FOR FLAMMABLE LIQUIDS, N.O.S.


GUIDE 128

POTENTIAL HAZARDS

FIRE OR EXPLOSION

HEALTH

PUBLIC SAFETY

PROTECTIVE CLOTHING

EVACUATION

EMERGENCY RESPONSE

FIRE

SPILL OR LEAK

FIRST AID

Source: DOT and others. 1996.